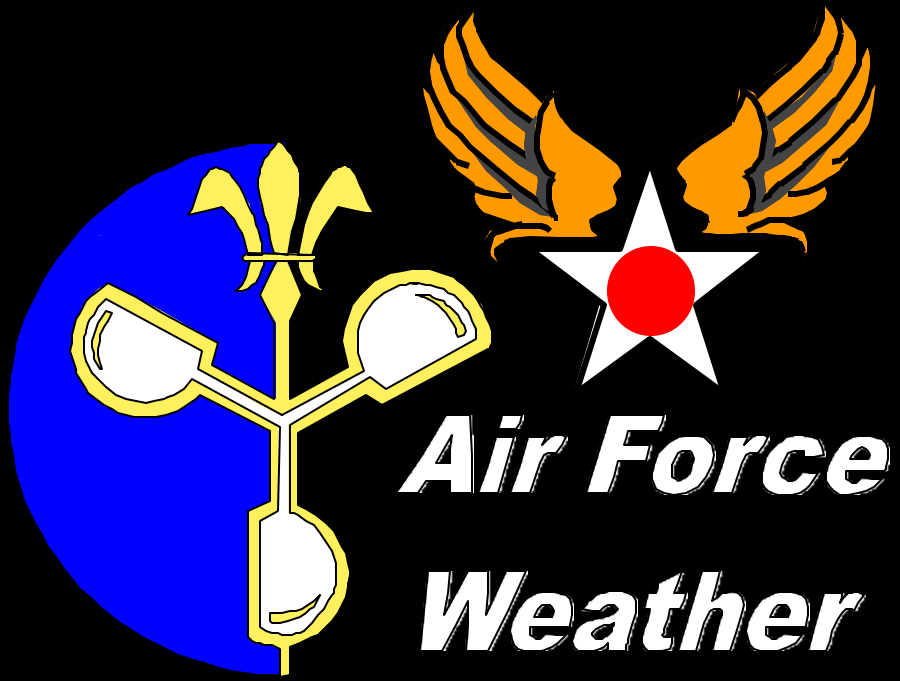
… on our Nation's team …

Weather Support for America's War Fighters



Colonel Michael A. Neyland

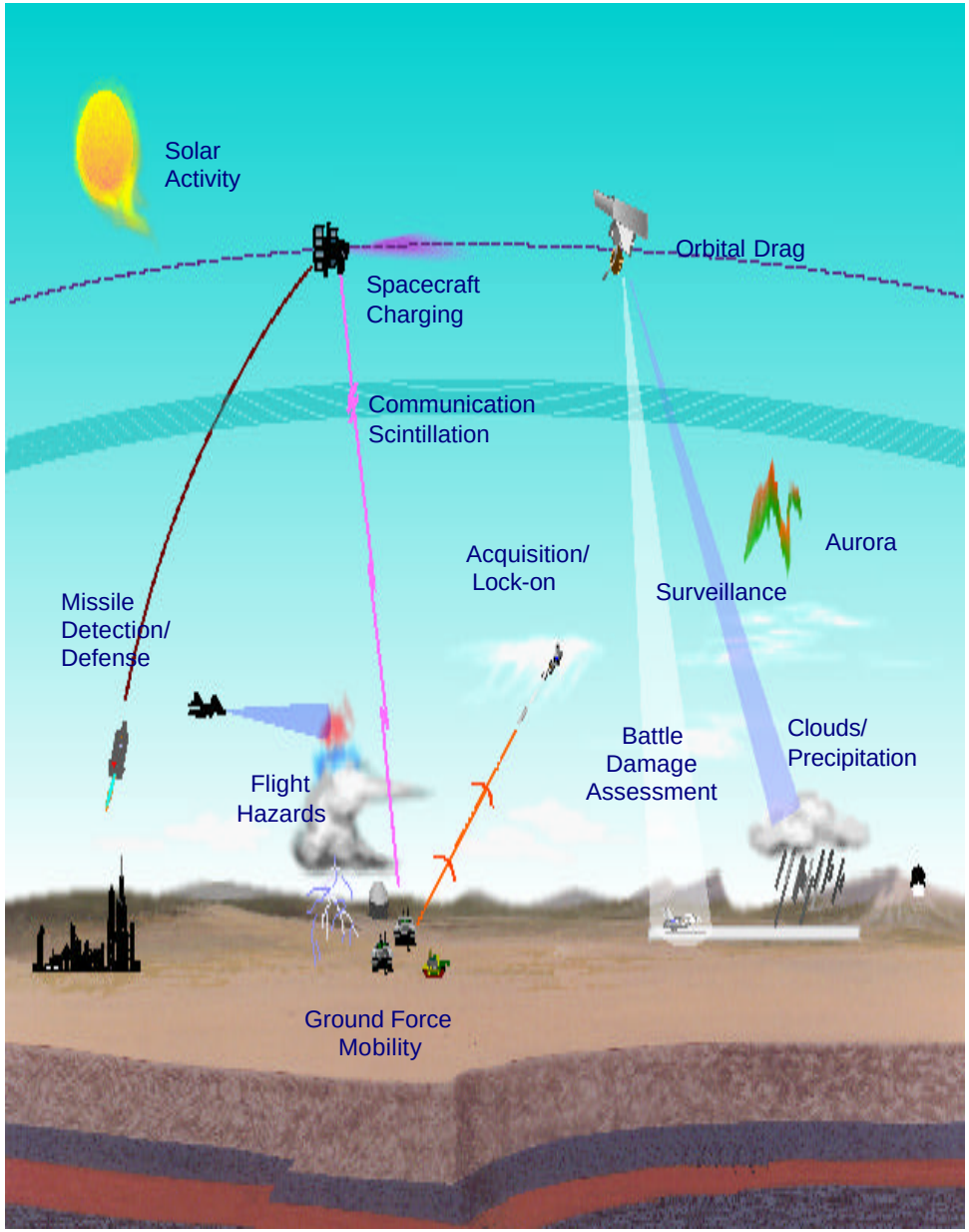
Deputy Director of Weather, HQ U.S. Air Force

Air Force Weather:

Mud to the Sun

The people of Air Force Weather provide information, products and services that support air, land, and space operations

-- truly from the mud to the sun



AFW
MISSION STATEMENT

"Deliver the highest quality mission-tailored weather and space environment information, products, and services to our Nation's combat forces...anytime, anyplace...mud to the sun."

To accomplish the AF mission, forces must be able to engage and prevail globally, by operating in the air and space environment, which can either enhance or degrade the effectiveness of systems and operations. It is the AFW mission to provide the highest quality, mission-tailored weather and space information--anytime, anywhere-from the mud to the sun.

MILITARY METEOROLOGY

"Know the weather …"

… to plan military operations
… to assess enemy capabilities
… to execute the military mission
… to protect war fighting resources

"Know yourself, know your enemy;
your victory will never be endangered.
Know the ground, know the weather;
your victory will be total …"
Sun Tzu, 500 B.C.

MILITARY METEOROLOGY

WEATHER AFFECTS VIRTUALLY ALL HUMAN ENDEAVOR

"Know the weather …"

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MILITARY METEOROLOGY

Weather Services

Today's military air & space operations stretch from the surface of the Earth to the realm of space. Experience from the beginnings of armed conflict has proven that the awareness or ignorance of the effects of the natural air & space environment can have **a decisive impact on war.** Decisions are enhanced by commanders integrating knowledge of the weather into every facet of military operations. **By understanding the impacts of the environment, opportunities can be anticipated and exploited, and the effects of mission-limiting weather can be mitigated**.

MILITARY METEOROLOGY

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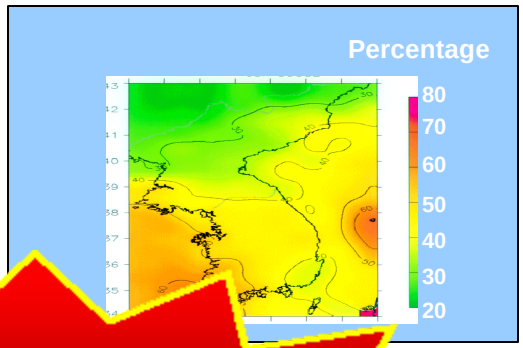
THE WEATHER ITSELF IS NOT NEARLY AS IMPORTANT AS WEATHER'S IMPACTS ON HUMAN ACTIVITIES

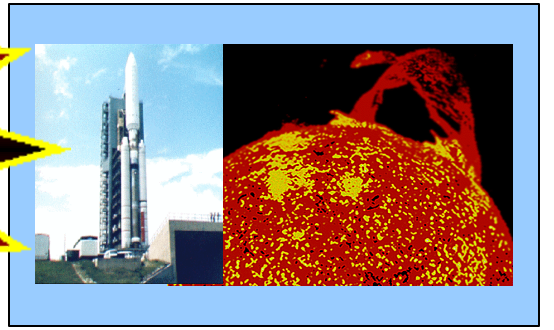
AFW: WHAT WE DO

Terrestrial Weather

Space Weather



Climatology

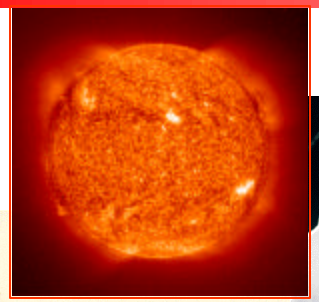


Ensuring DoD Operators can "Exploit the Weather"

"From the Mud to the Sun"

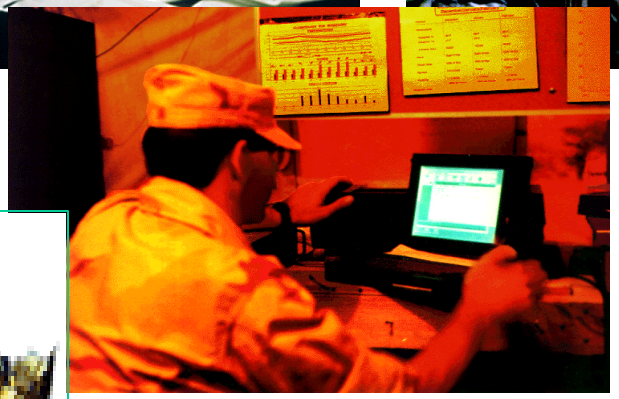
CORE PROCESSES
AIR & SPACE

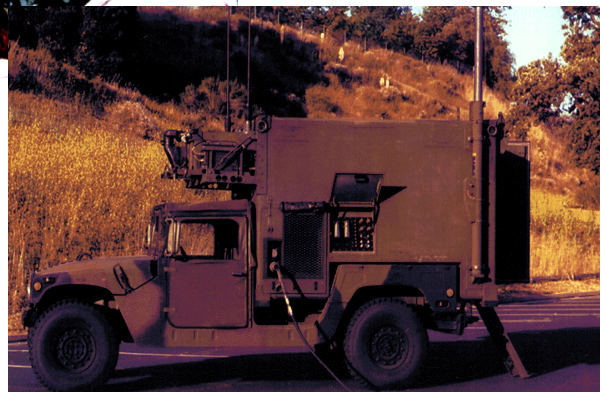
ALL KEY TO PERFORMING AFW'S MISSION

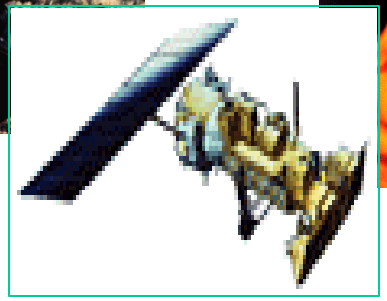


ANALYSIS

TAILORING







FORECASTING

DISSEMINATION

DATA COLLECTION

TERRESTRIAL WEATHER

Timely Accurate Relevant

DATA COLLECTION

- Surface / upper air obs
- Satellite soundings
- Cloud imagery (all METSATs)
- Radar / lightning data
- Space weather obs
- Nontraditional obs (GPS)

OUR MOST BASIC MISSION

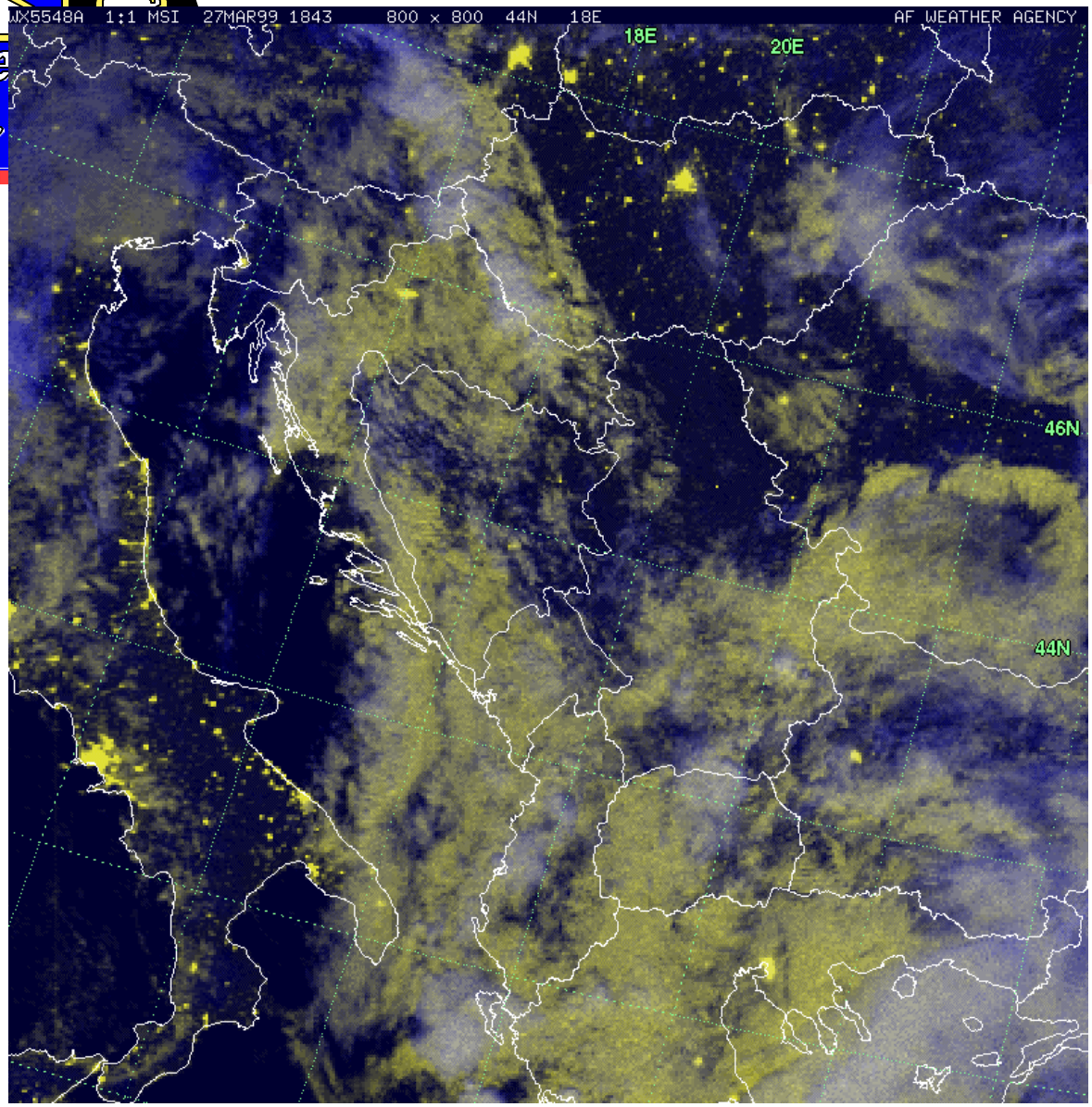
TERRESTRIAL WEATHER

Timely Accurate Relevant

Weather Parameters

- Temperature
- Humidity
- Winds
- Pressure
- Clouds
- Visibility
- Precipitation (Amount & Type)
- Cloud-free Line of Sight
- Severe Weather (tornadoes, hail, winds over 35 knots)
- Hazards
- Turbulence
- Icing

Multispectral DMSP Imagery



Operation Allied Force

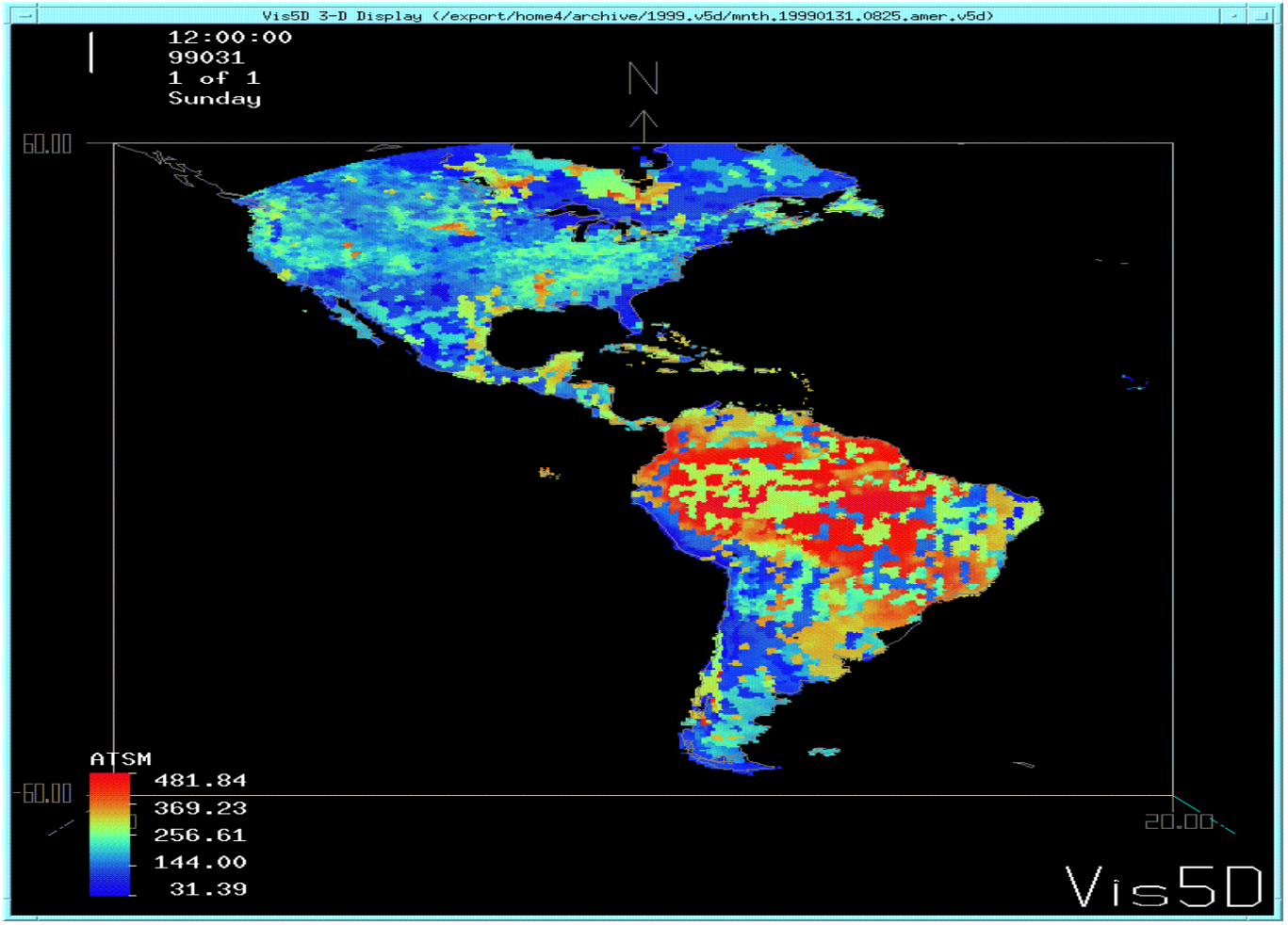
27 Mar 99

Agricultural Meteorology (AGRMET)

Jan 99 Top Soil Moisture

(Cubic inches of water / Cubic inches of soil sample)

Analysis of surface parameters (soil moisture, etc.)



TERRESTRIAL WEATHER

Timely Accurate Relevant

NUMERICAL WEATHER PREDICTION PROCESS

- **Application models (use output from global and theater fine-scale models)**
  - **Cloud forecasts, thunderstorm forecasts**
  - **Aviation and maneuver parameters**
  - **Slant path profiles, cloud-free line of sight**
  - **Agricultural meteorological analysis**
  - **Tactical decision aids**

TERRESTRIAL WEATHER

Timely Accurate Relevant

- Support to US Army/AF Ground Operations
  - Trafficability
  - Ground/Aviation Ops in Lowest 3000 Ft
  - Valley-By-Valley Ops
  - EO weapons and sensor support
  - Snow Cover
  - River Flooding
  - Soil Conditions
  - Terrain/Vegetation
  - Vehicle Operations
  - Troop Movement
  - Axes of Advance

TERRESTRIAL WEATHER

Timely Accurate Relevant

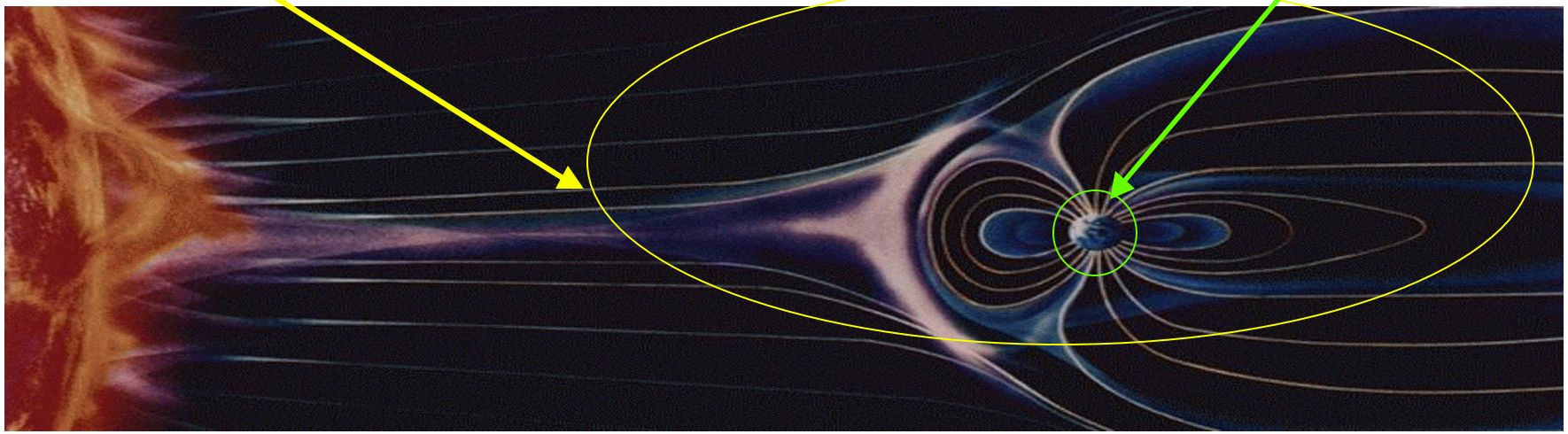
- Resource Protection
  - Precise forecasts of threatening weather conditions that endanger people, resources, or operations
  - Tornadoes
  - High Winds
  - Hail
  - Lightning
  - Floods
  - Heavy Snow/”Blizzard”
  - Excessive Temperatures
  - Sand Storm

SPACE WEATHER

Key to 21st Century Warfare

Weather - - Environmental Disturbances Generated by the Sun

Space Weather ⟵ ***Seamless Battlespace Environment*** ⟶ **Terrestrial Weather**



Space Weather: Electromagnetic radiation and electrically-charged particles stream outward from the sun, envelop the earth, and interact with the earth's magnetic field and terrestrial atmosphere creating an adverse environment.

SPACE WEATHER

Key to 21st Century Warfare

Air Force Weather

ISSUE
Military Operations Depend on Electronically Sensitive Space and Ground Systems Which Fail Due to Severe Space Weather

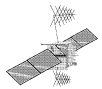
IMPACT
The Proliferation of These Systems Without a Complementing Space Weather Capability Will Fracture the Seamless Battlespace

STATUS
Multi-Hundred Billion Dollar Investment Not Optimized

MAGNETOSPHERE
30+ Satellites

DSP
MILSTAR
DSCS

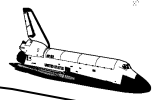
RADIATION BELTS
25+ Satellites



GPS

IONOSPHERE
25+ Satellites

DMSP



SHUTTLE

MESOSPHERE

STRATOSPHERE

TR-1

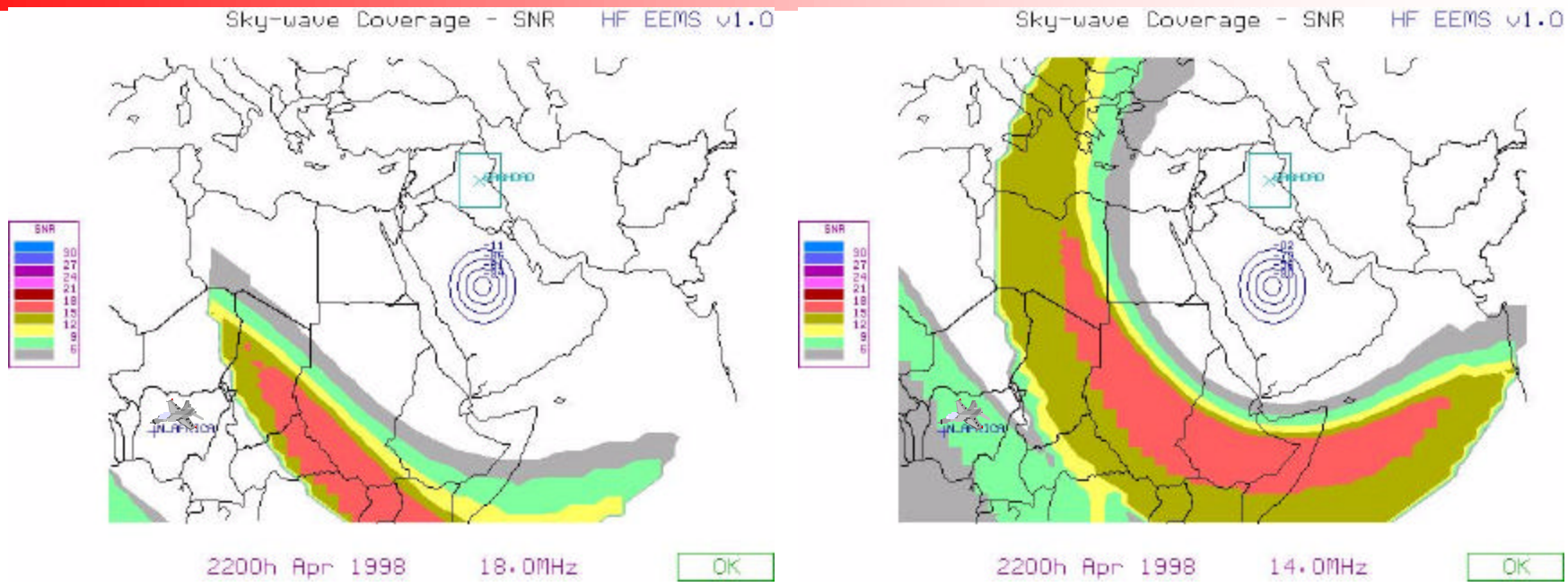
TROPOSPHERE

Space Weather
Terrestrial Weather

SEAMLESS BATTLESPACE

TECHNOLOGIES:
Space Weather

HF Illumination Maps
Scenario #1: Link Establishment

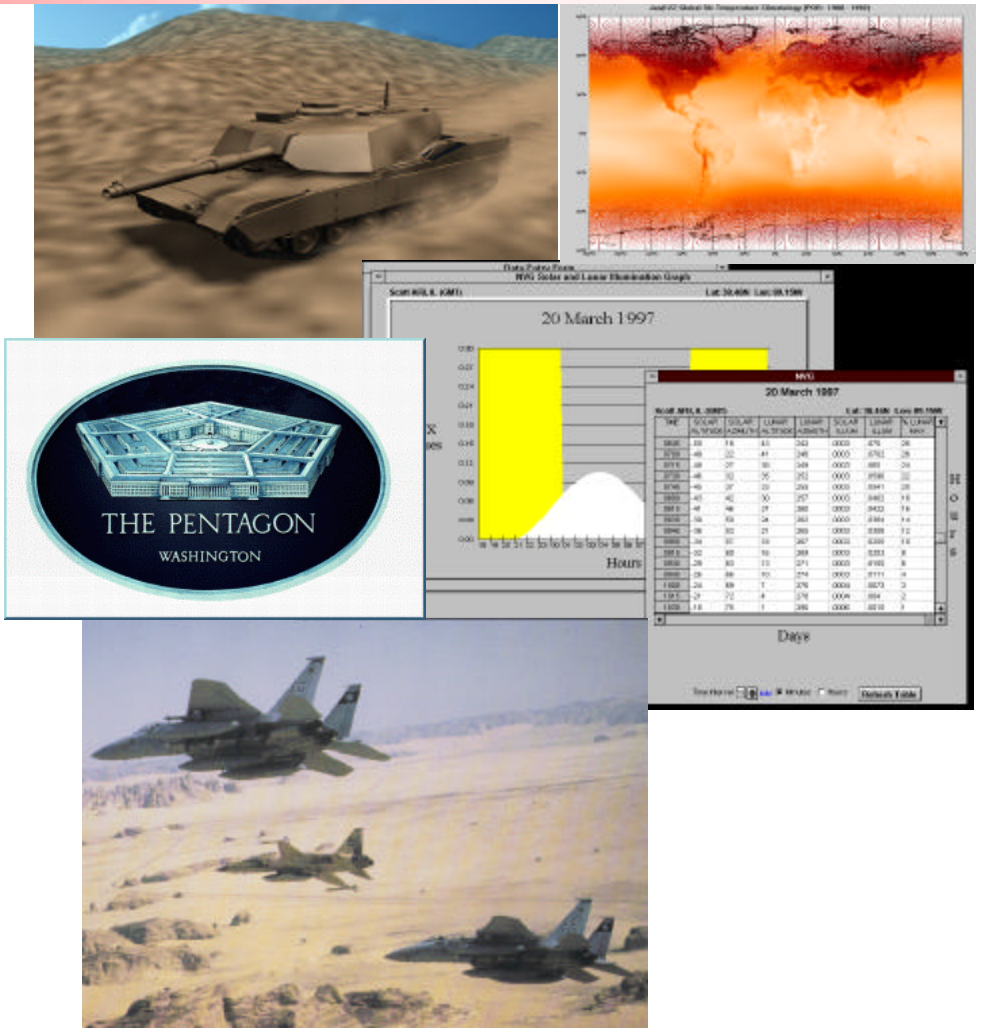


- Correct frequency selection allows HF link establishment
- Illumination maps also facilitate jammer location, sigint denial, and enhanced OTH surveillance

CLIMATOLOGY

Key to Effective Planning

- "Long Range" forecasts
- Planning / Operations climatology assessments (operational weather impacts)
- Short-notice contingency response planning information
- Engineering design and employment of weapons systems



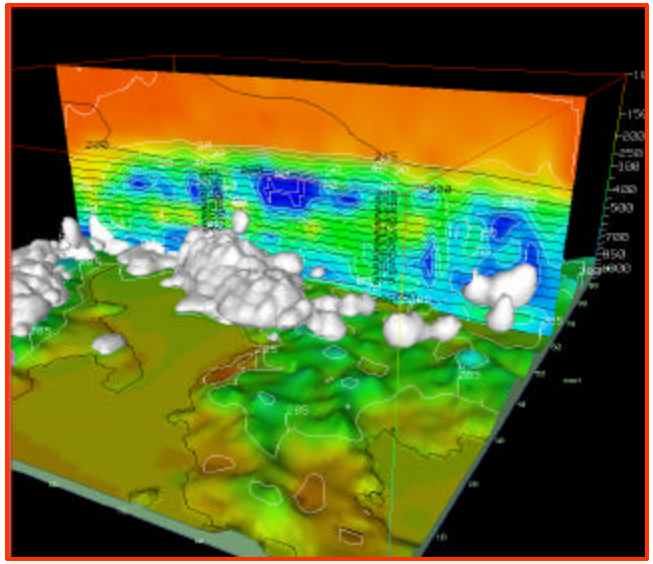
LEVERAGING TECHNOLOGIES

Enable Us to Excel

- **Leveraging National and Commercial Capabilities**
  - Navy-Air Force cooperation agreement
  - Air Force-Army partnering continues strong (ARL support)
  - Federal agency partnerships
    - AFW provides backup support to SPC, AWC, NCEP
    - FAA and DOA partnerships
  - Universities, researchers & contractors
- **Mission-Scale Meteorology**
  - Operationalized, fine-scale models
  - Meteorological satellite & space weather expertise
  - Weather effects visualization

LEVERAGING
Weather Forecast Models

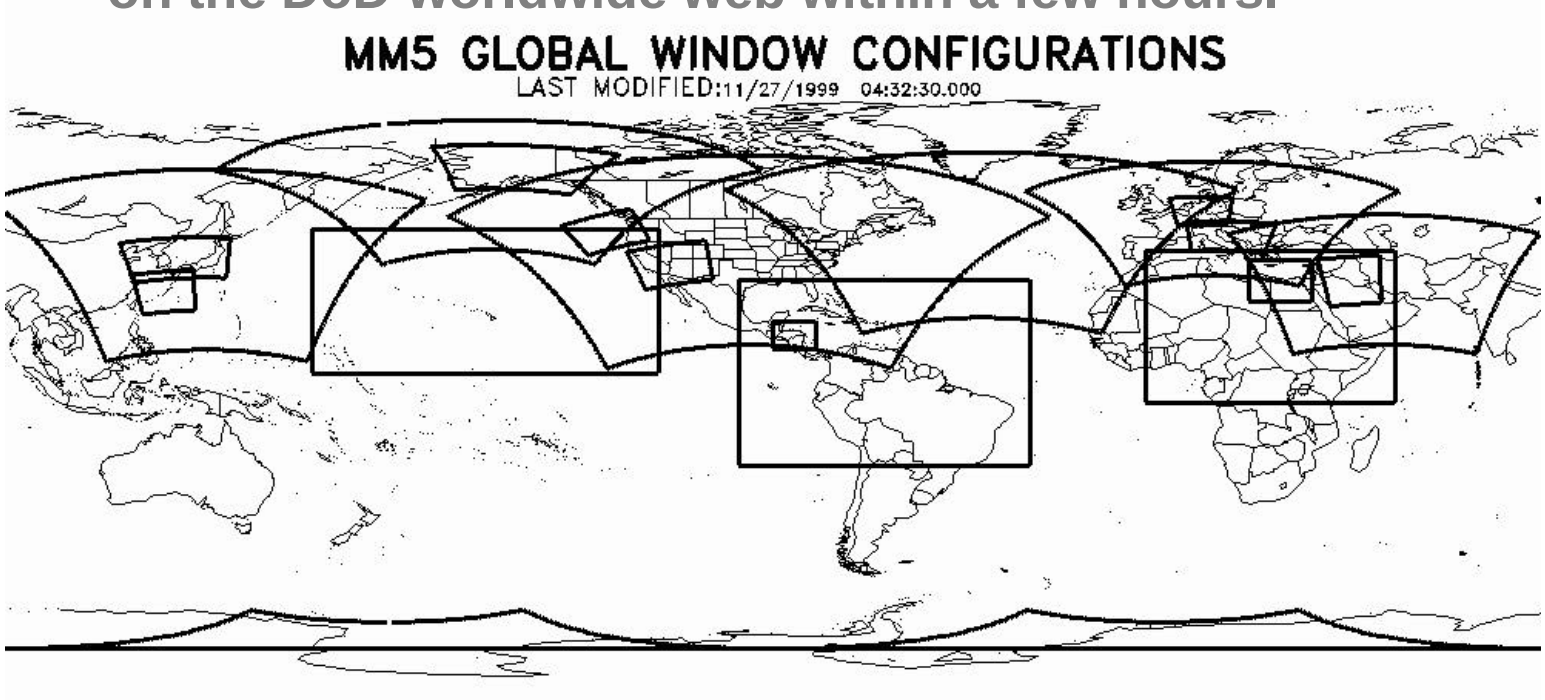
- **NOAA & Navy run global, large scale forecast models.**
  - Used to forecast large-scale (global) weather systems
  - AFW uses output from NOAA & Navy
- **AFW runs High Resolution Mesoscale and Specialized Weather Models**
  - Used to forecast smaller scale weather systems
  - NOAA and research community develops mesoscale models
  - AFW adapts models for daily use to support worldwide military operations with fine-scale, accurate, relevant wx info



TECHNOLOGIES

FOCUS ON SIGNIFICANT EVENTS / WEATHER

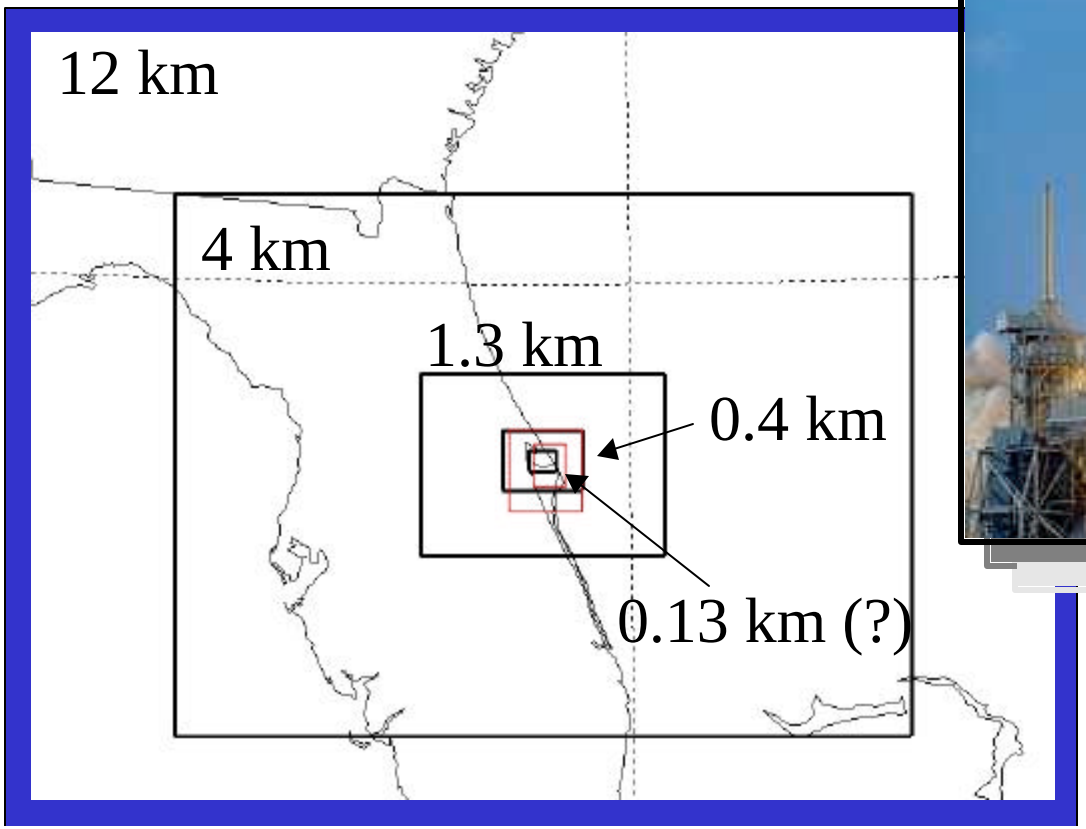
Precision Forecasting … Anywhere, Anytime!
Rapidly relocate fine-scale analysis and forecast windows around the world. Visualization products on the DoD worldwide web within a few hours.



Typical MM5 Window Locations

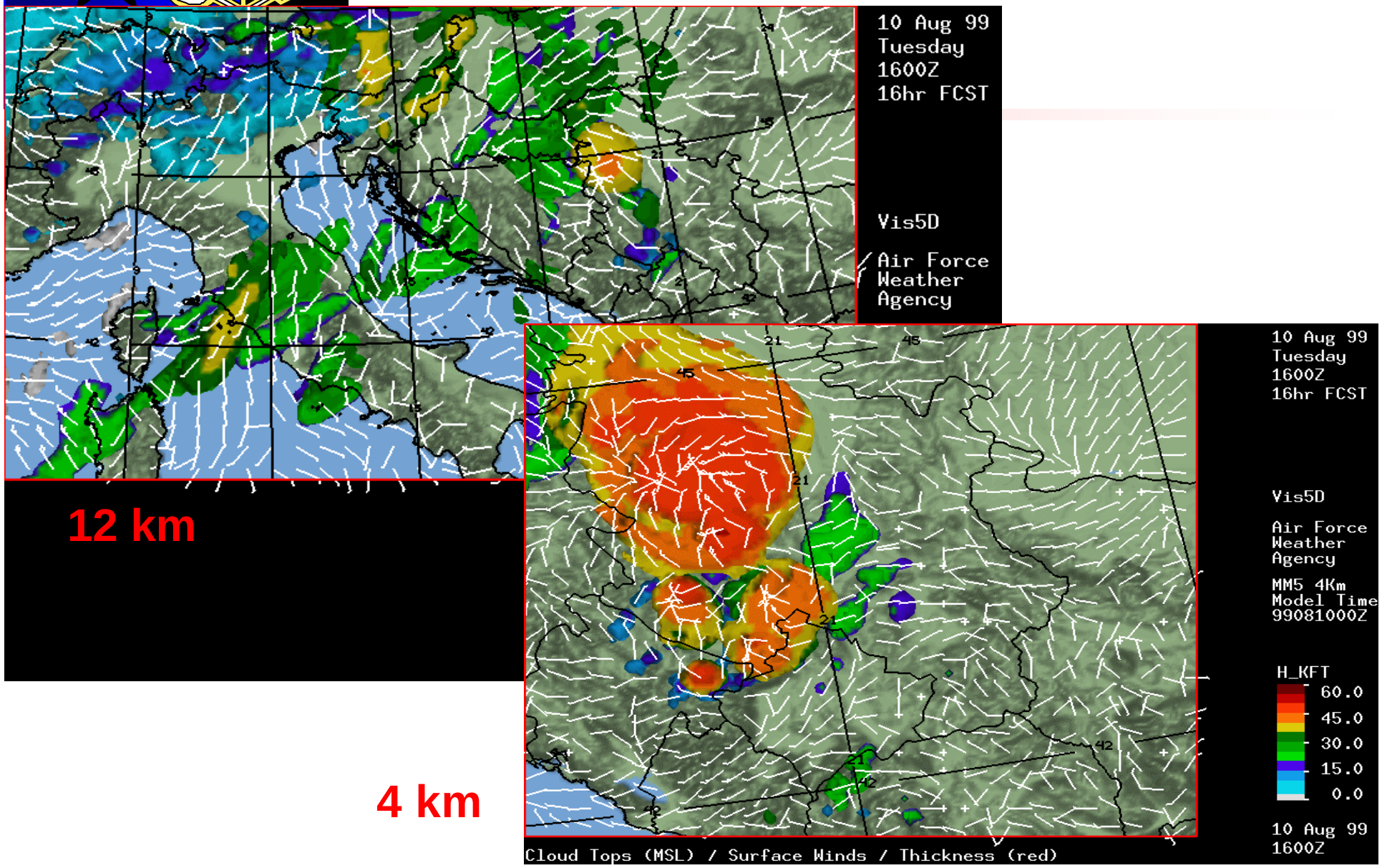
Another Window Possibility Space Shuttle Launch or Operational Target

Finest resolution for critical forecasts



TECHNOLOGY

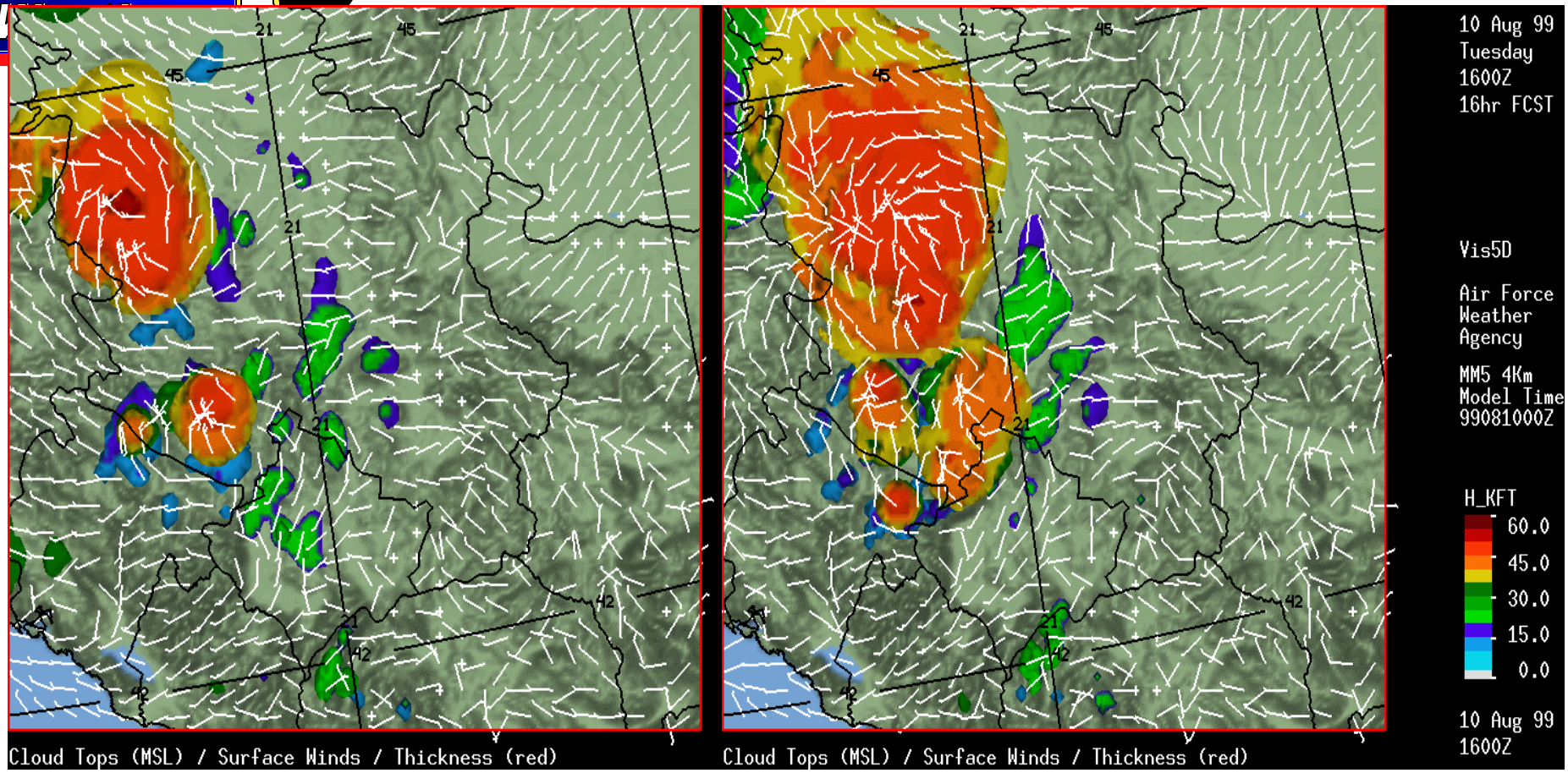
FINE-SCALE FORECASTING MODELS



TECHNOLOGY

FINE-SCALE FORECASTING MODELS

4 km MM5

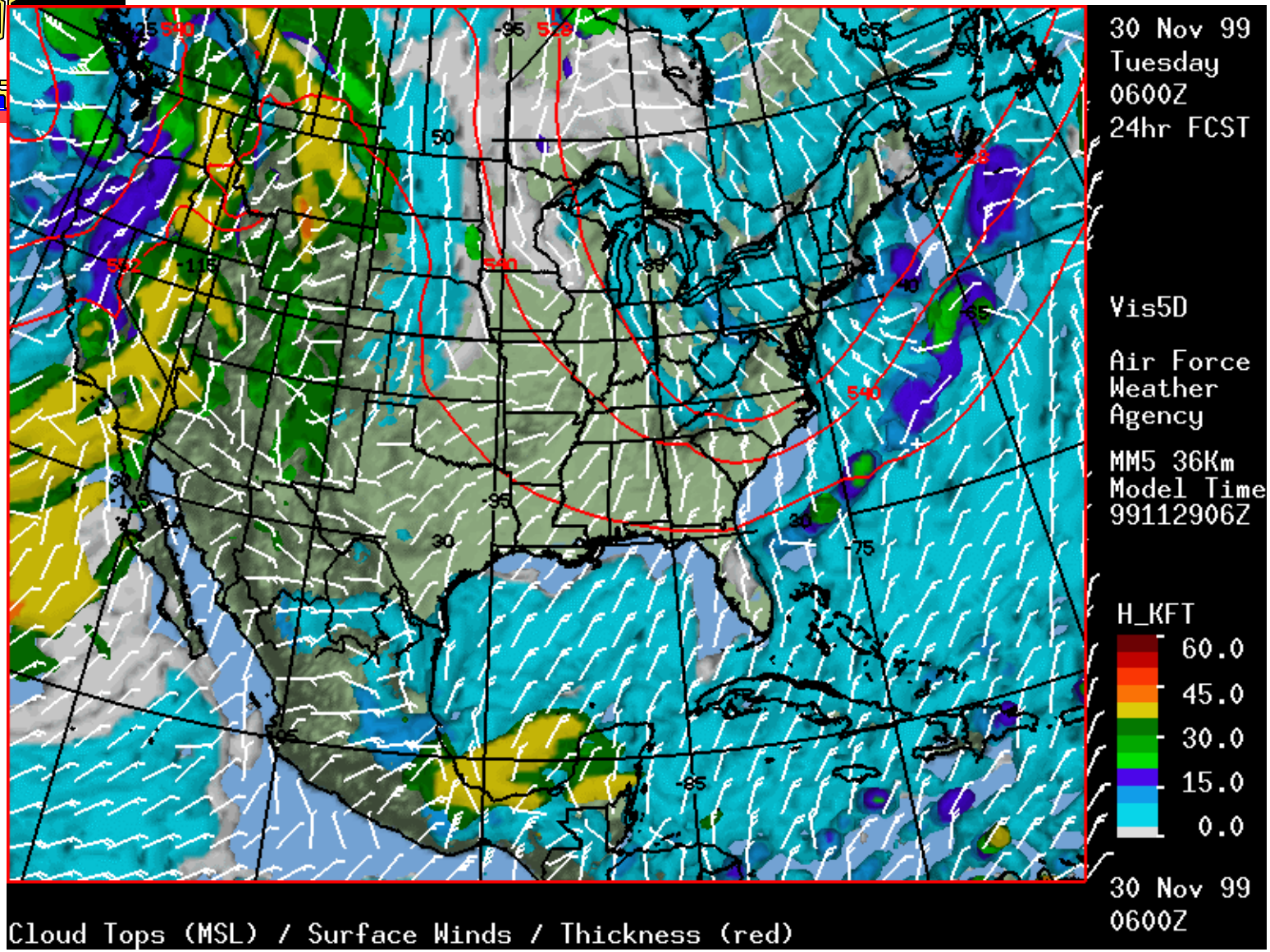


15Z 10 Aug **16Z 10 Aug**

Balkans

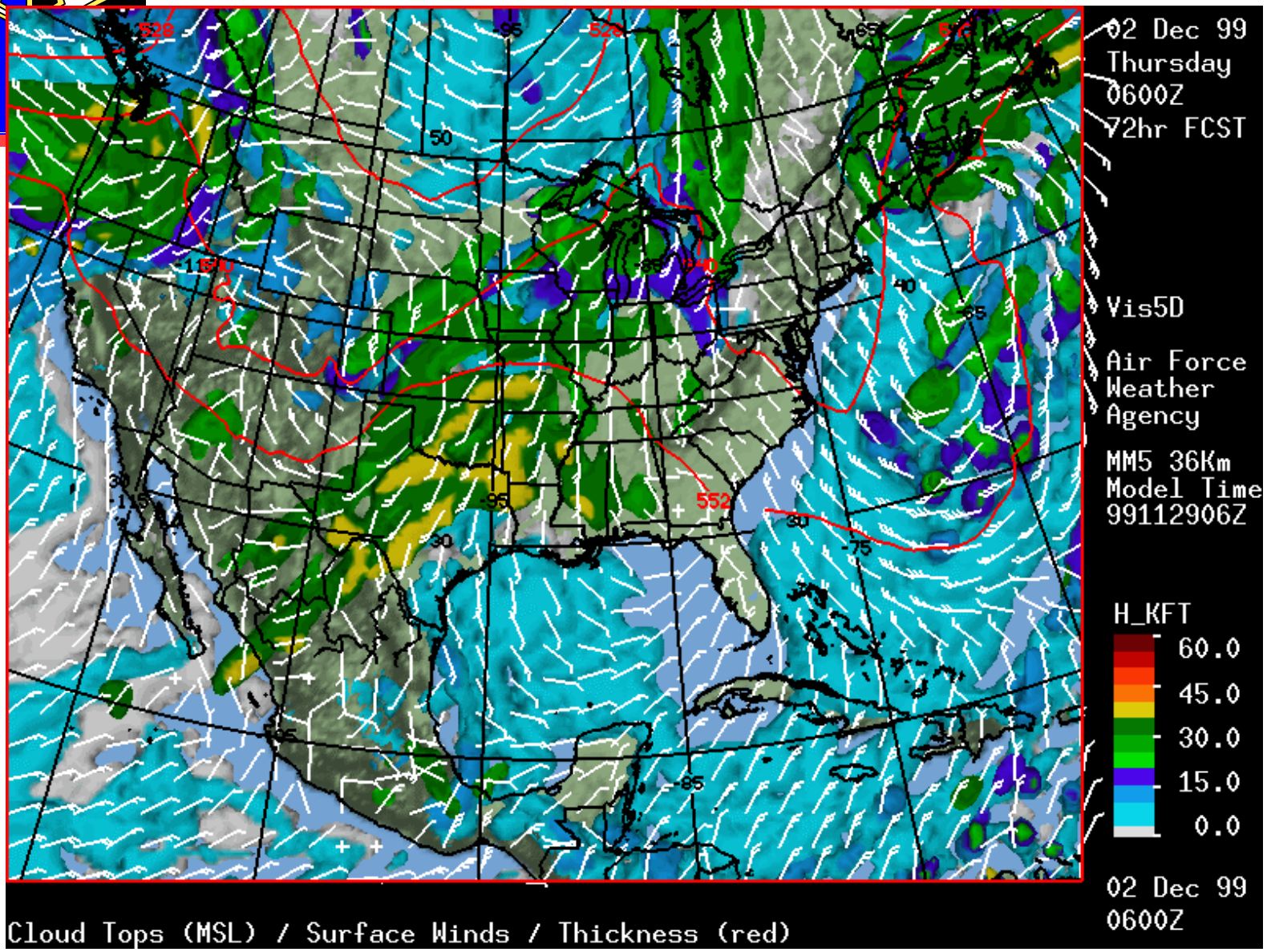
MM5 36km Cloud Tops/Surface Winds

24 Hr Forecast Valid 30 Nov 06Z



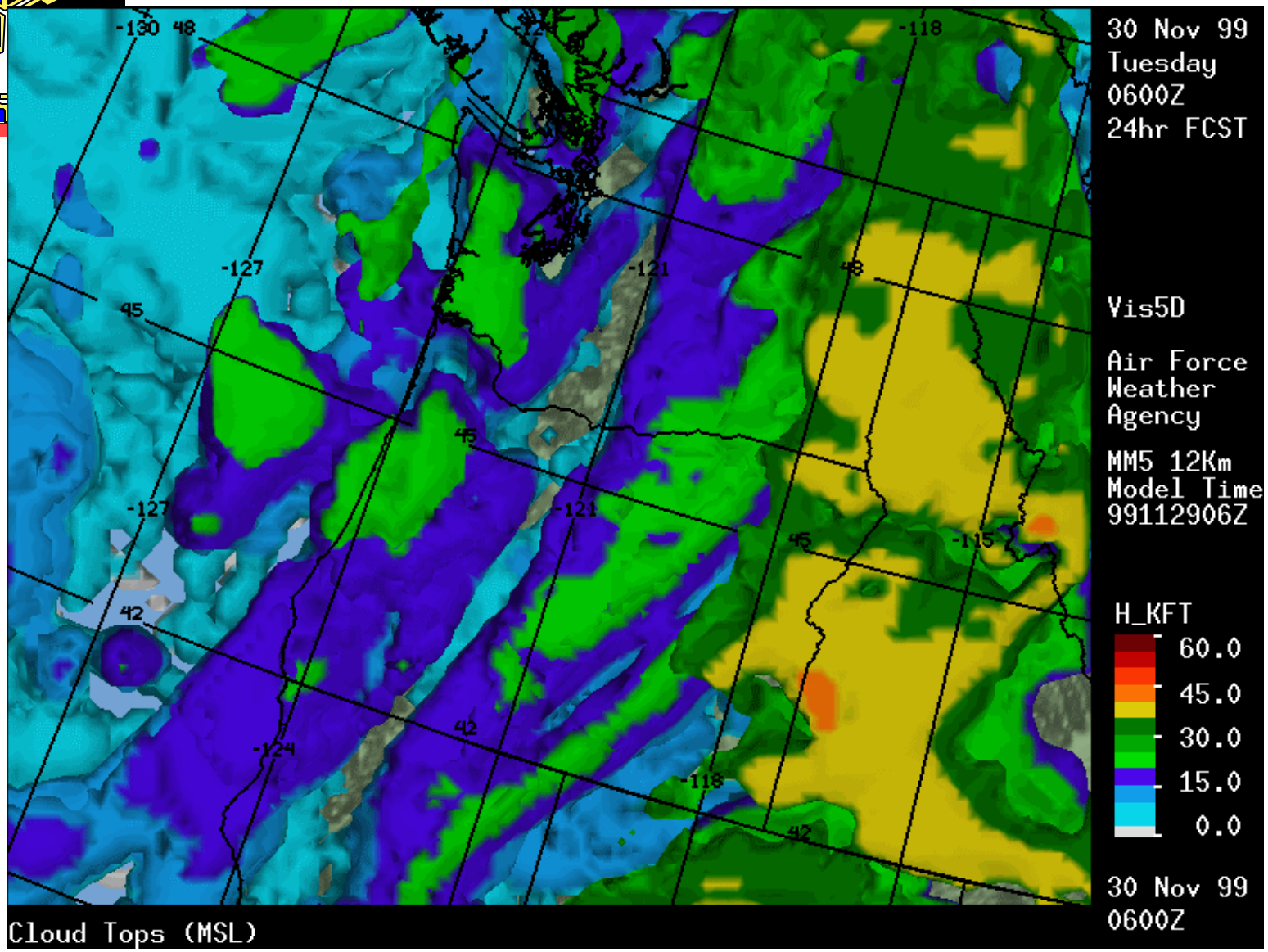
MM5 36km Cloud Tops/Surface Winds

72 Hr Forecast Valid 2 Dec 06Z



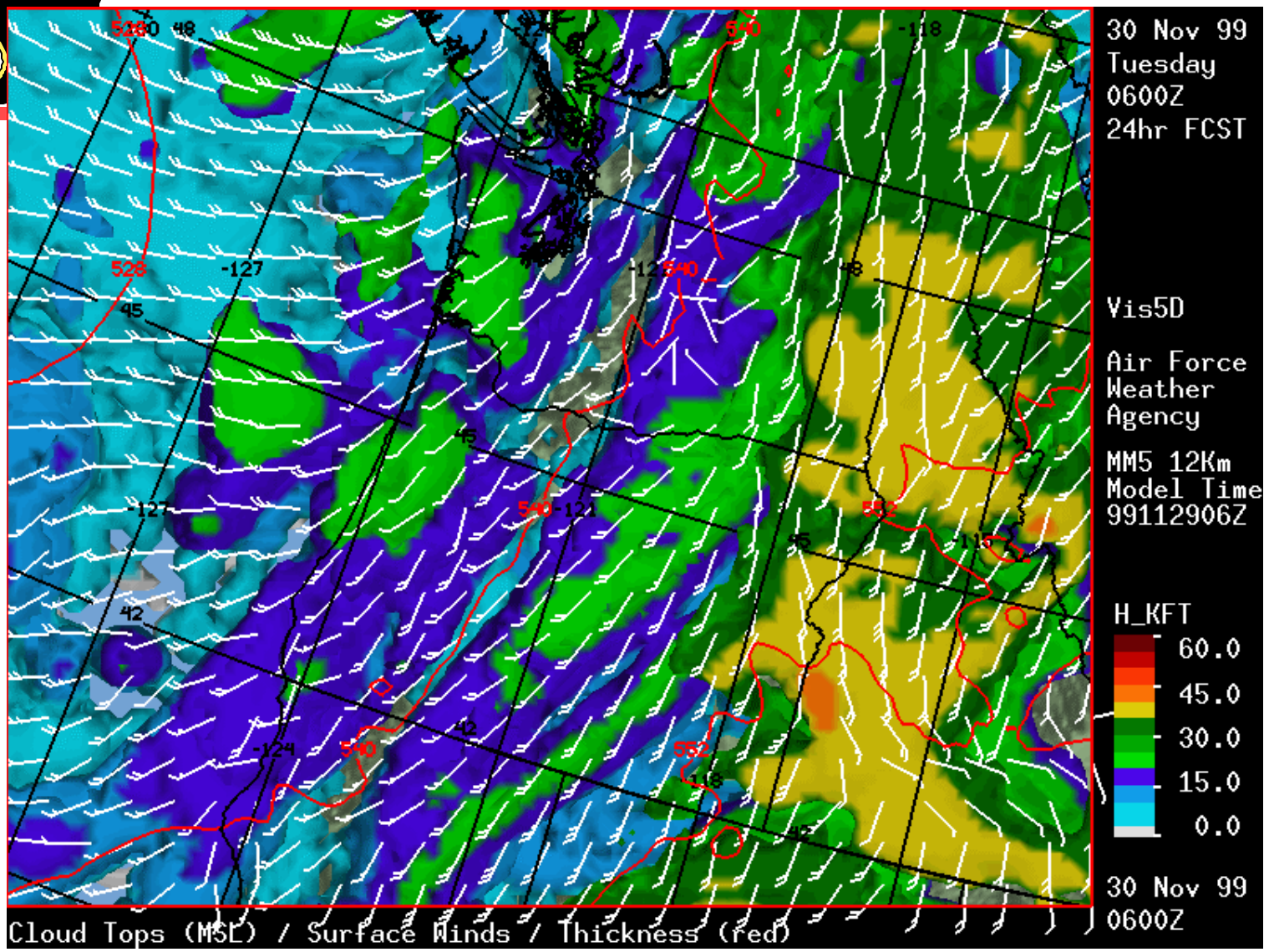
MM5 12km Cloud Tops Image

24 Hr Forecast Valid 30 Nov 06Z



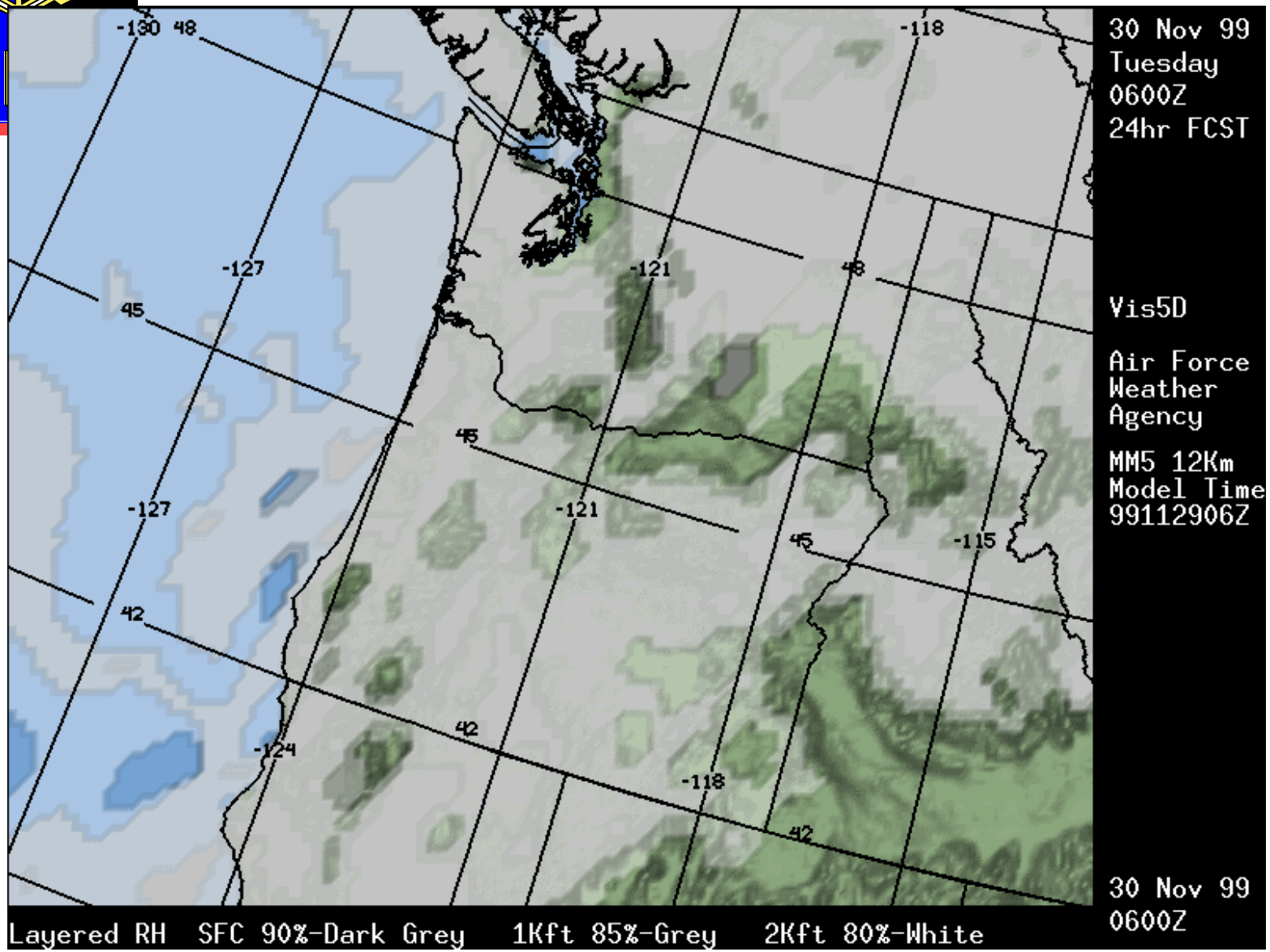
MM5 12km Cloud Tops/Surface Winds

24 Hr Forecast Valid 30 Nov 06Z



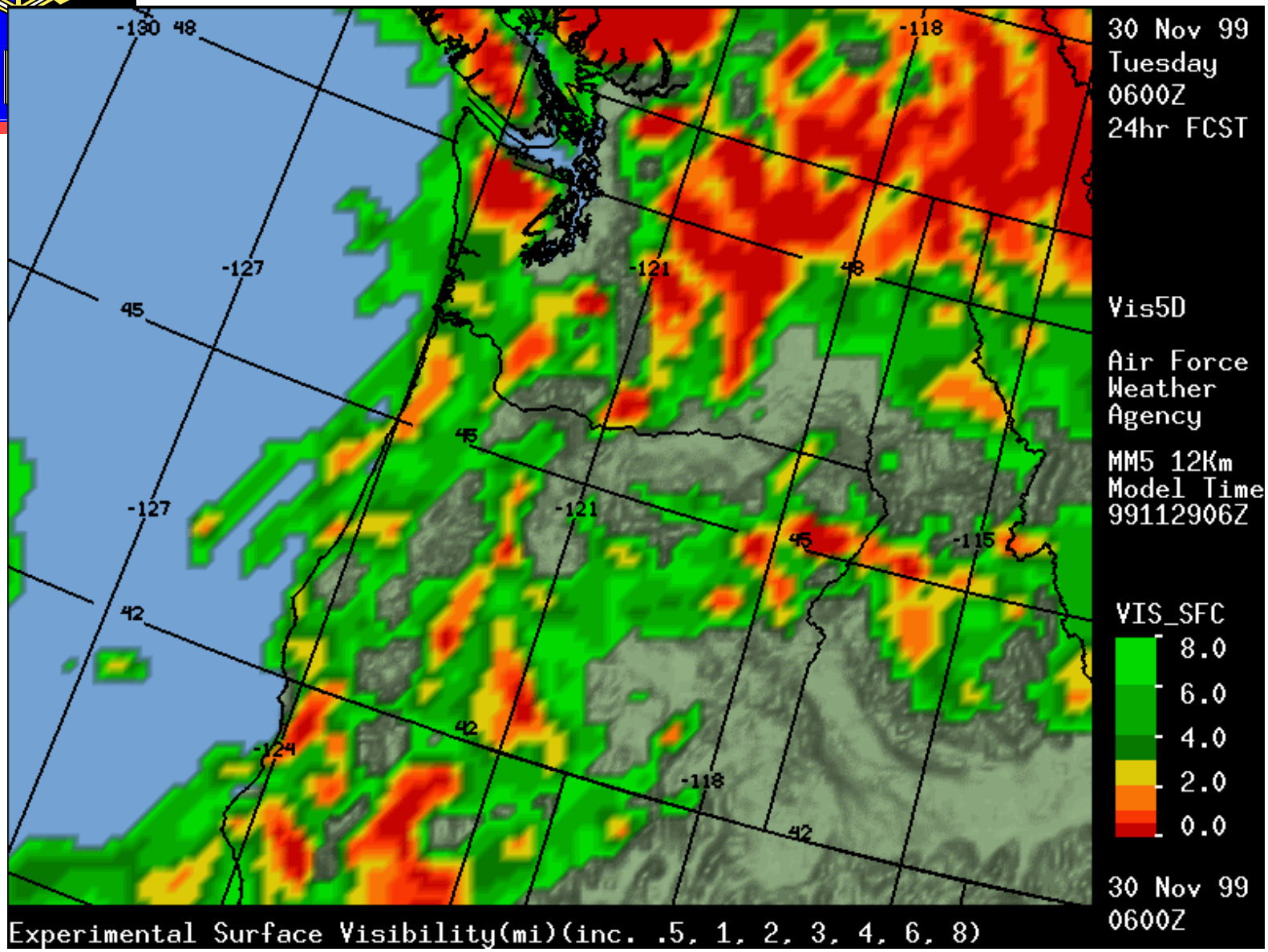
MM5 12km Low Clouds and Fog

24 Hr Forecast Valid 30 Nov 06Z



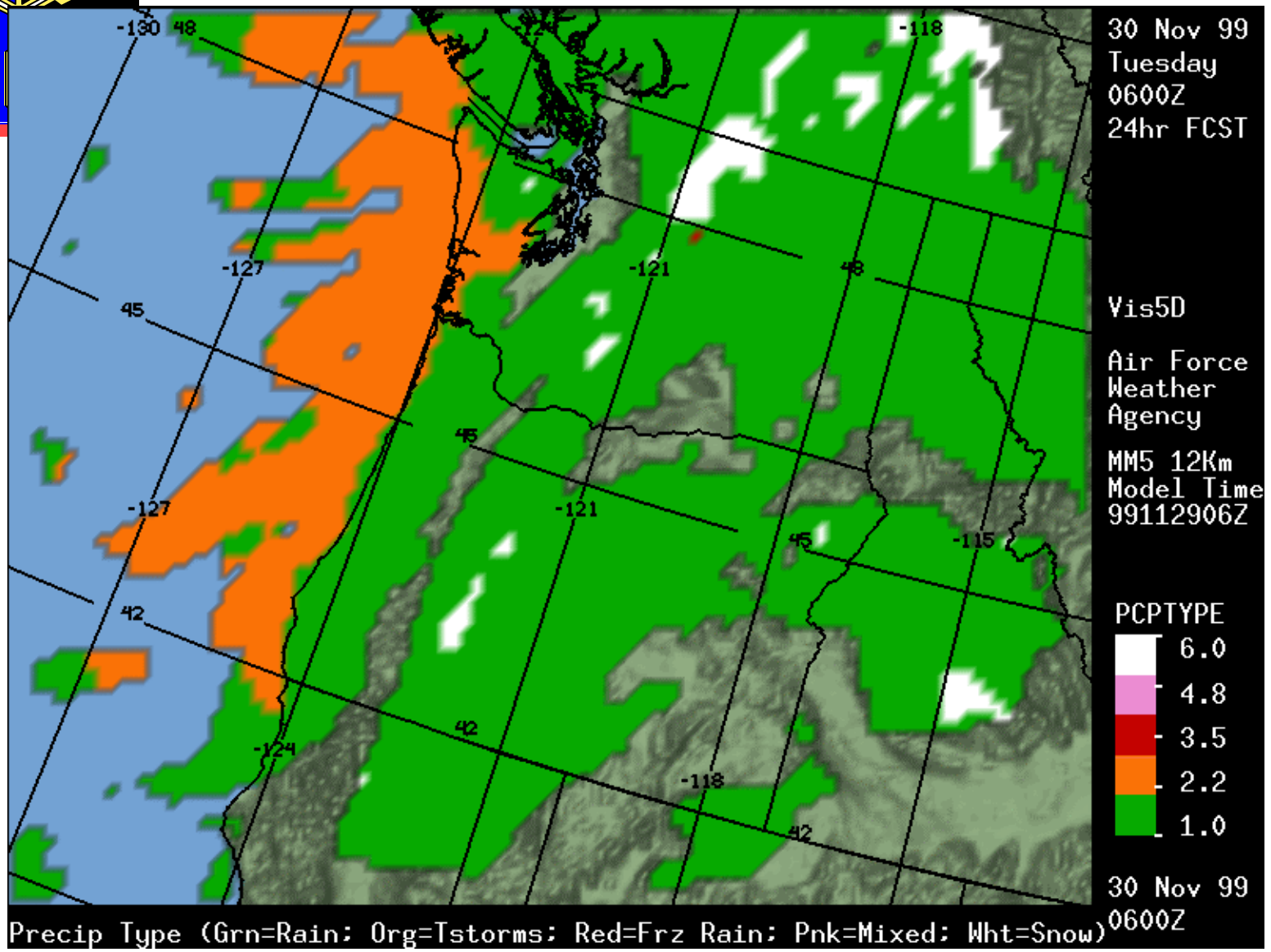
MM5 12km Surface Visibility

24 Hr Forecast Valid 30 Nov 06Z



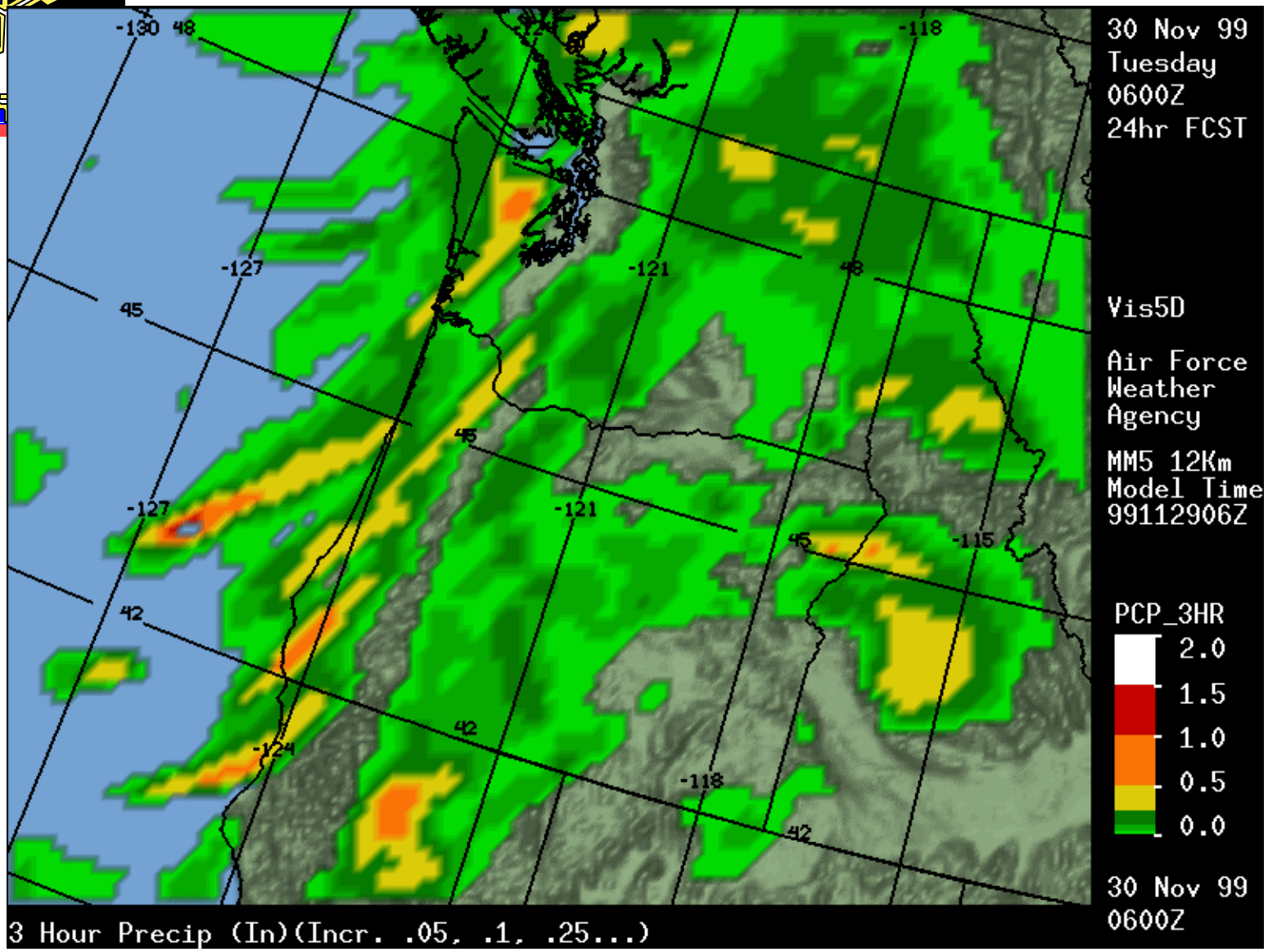
MM5 12km Precipitation Type

24 Hr Forecast Valid 30 Nov 06Z



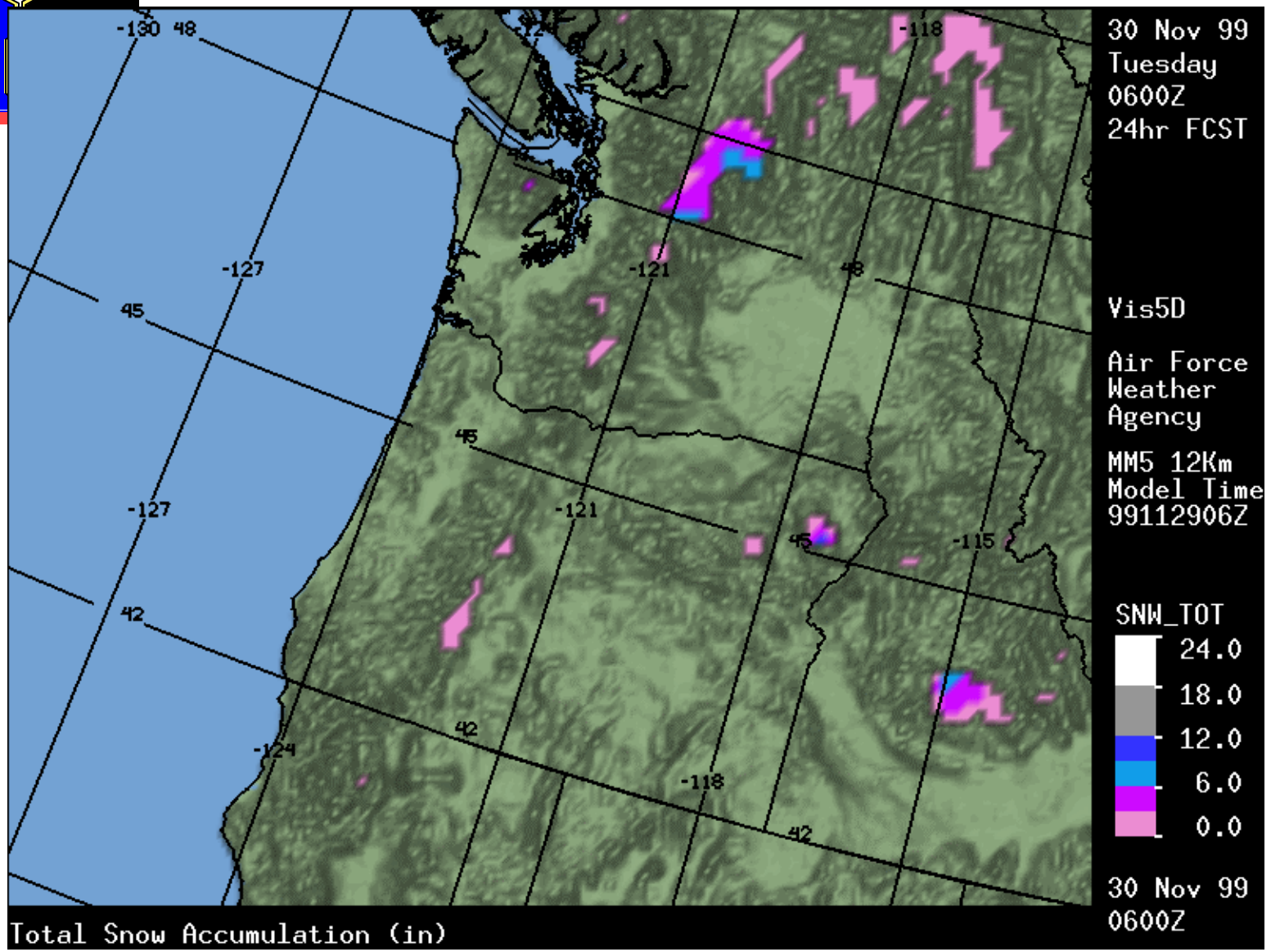
MM5 12km 3 Hr Precip Accumulation

24 Hr Forecast Valid 30 Nov 06Z



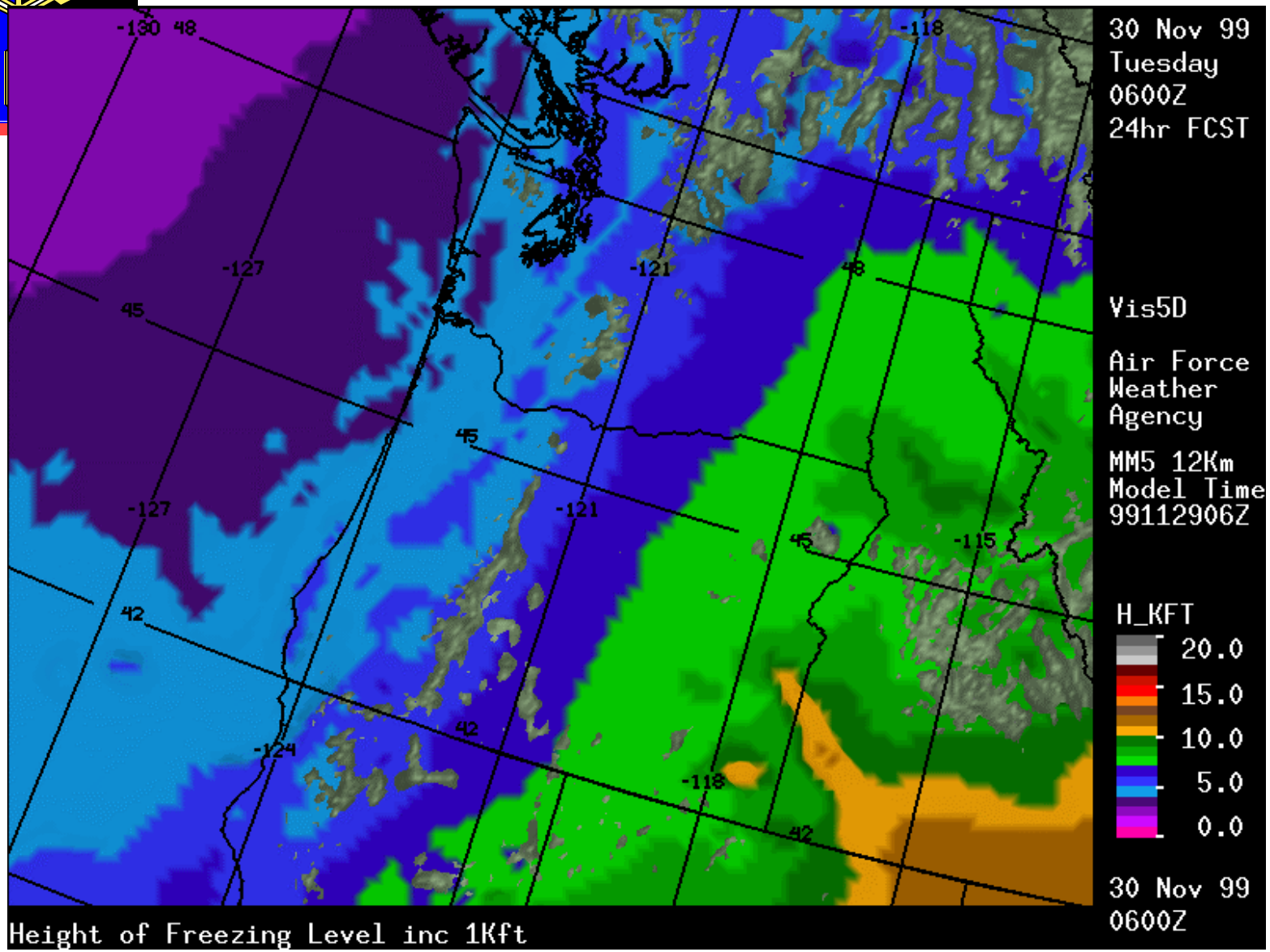
MM5 12km Total Snow Accumulation

24 Hr Forecast Valid 30 Nov 06Z



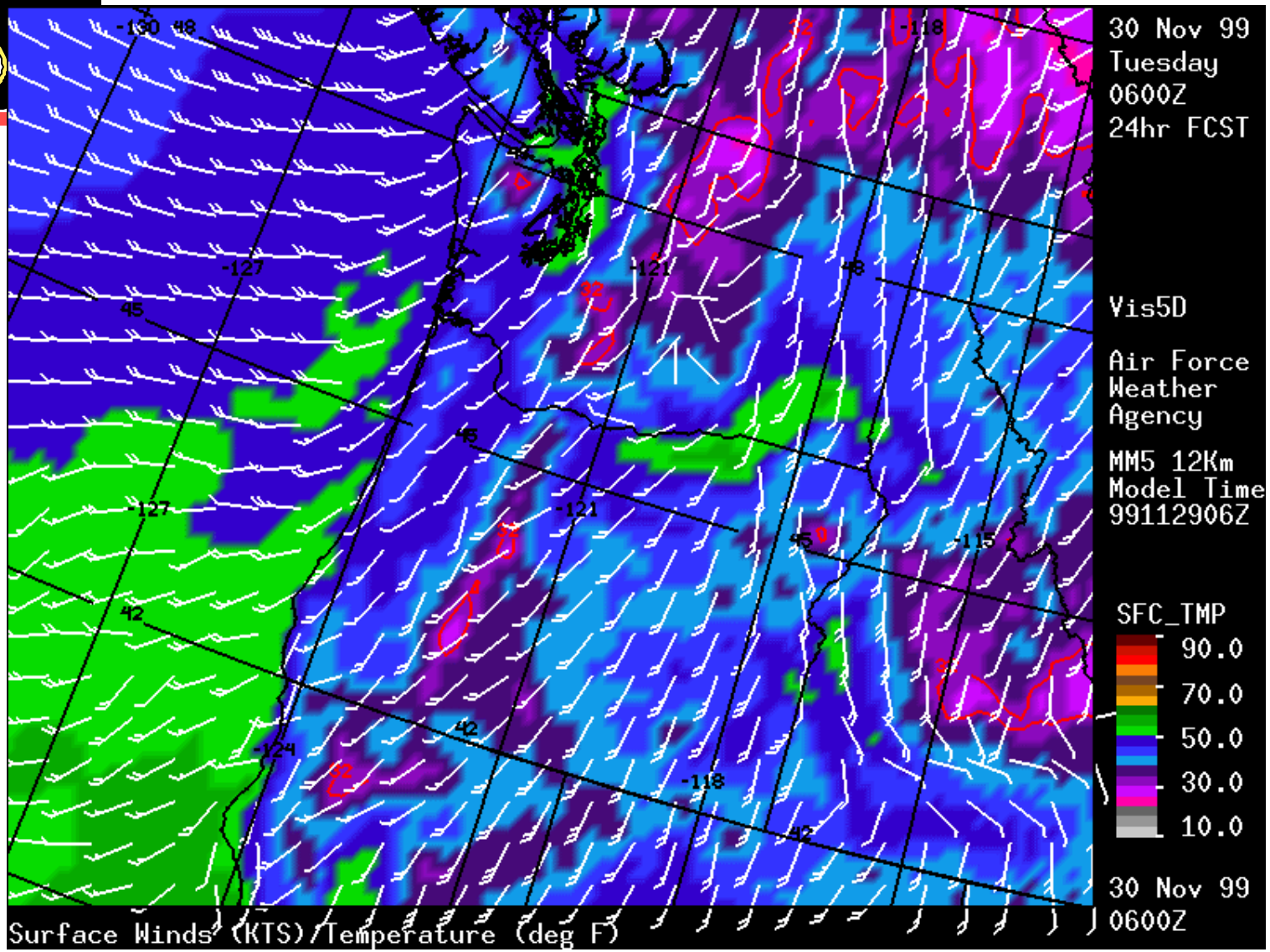
MM5 12km Height of Freezing Level

24 Hr Forecast Valid 30 Nov 06Z



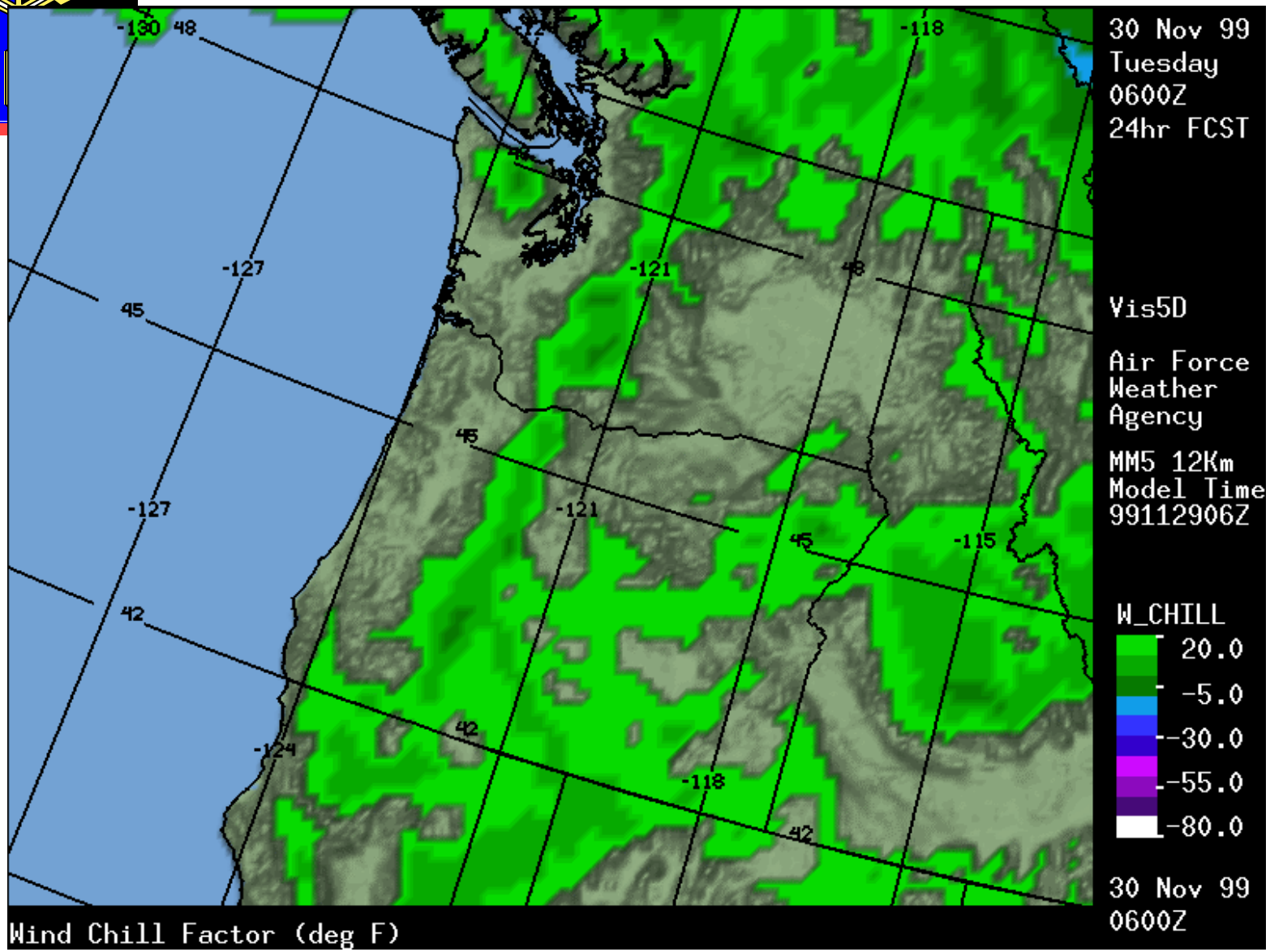
MM5 12km Surface Winds/Temperature

24 Hr Forecast Valid 30 Nov 06Z

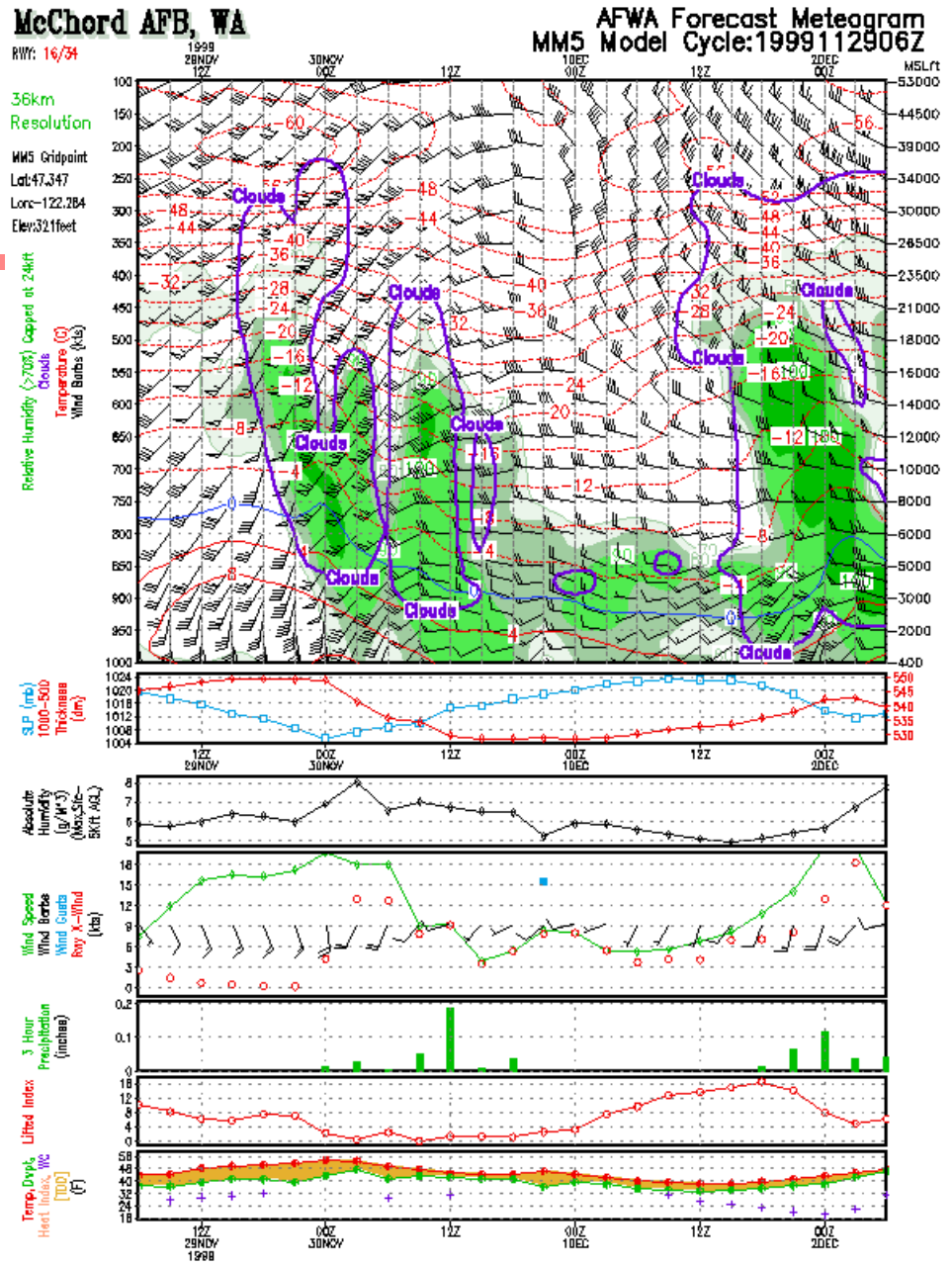


MM5 12km Wind Chill Factor

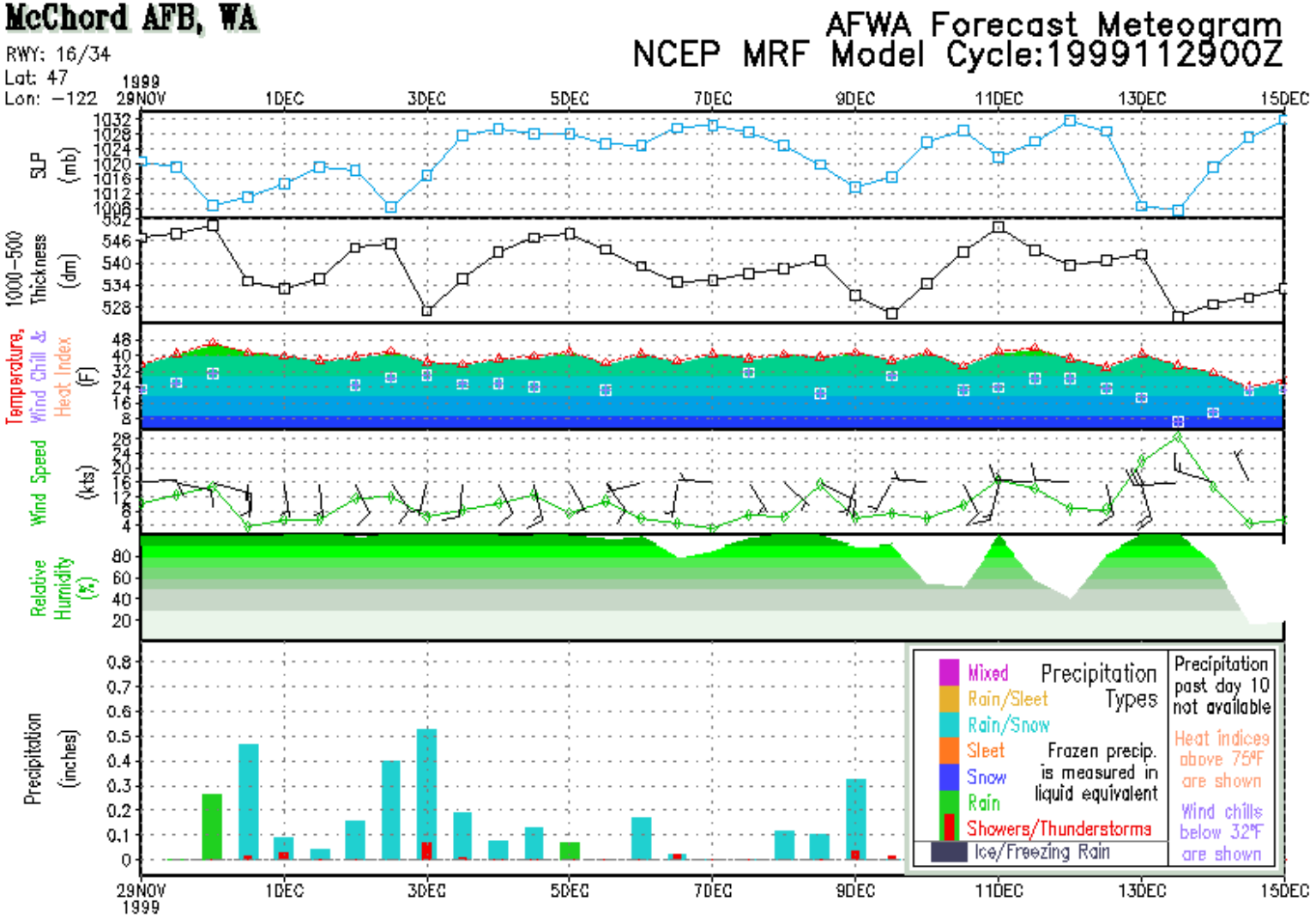
24 Hr Forecast Valid 30 Nov 06Z



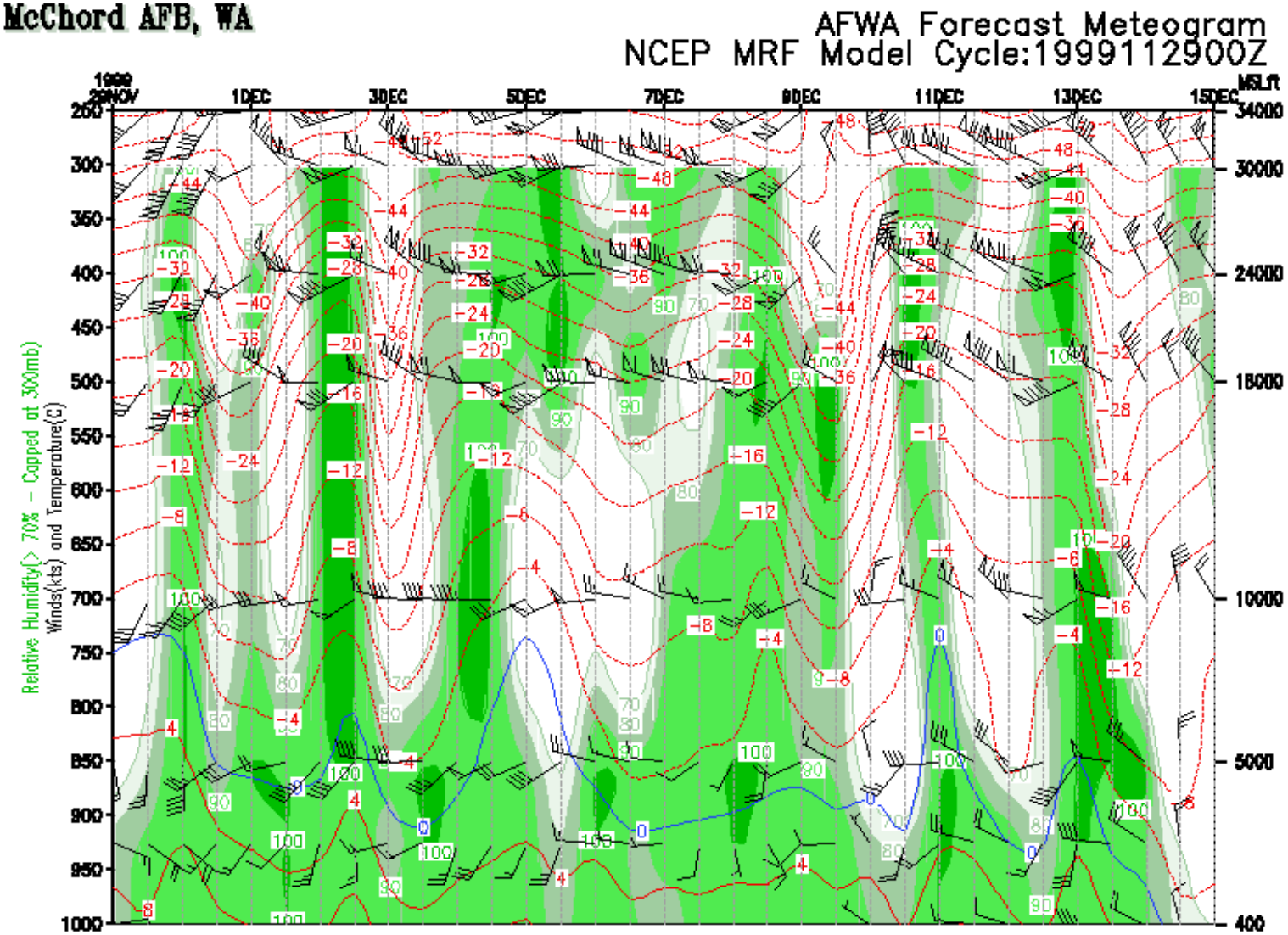
MM5 Meteogram Near Seattle



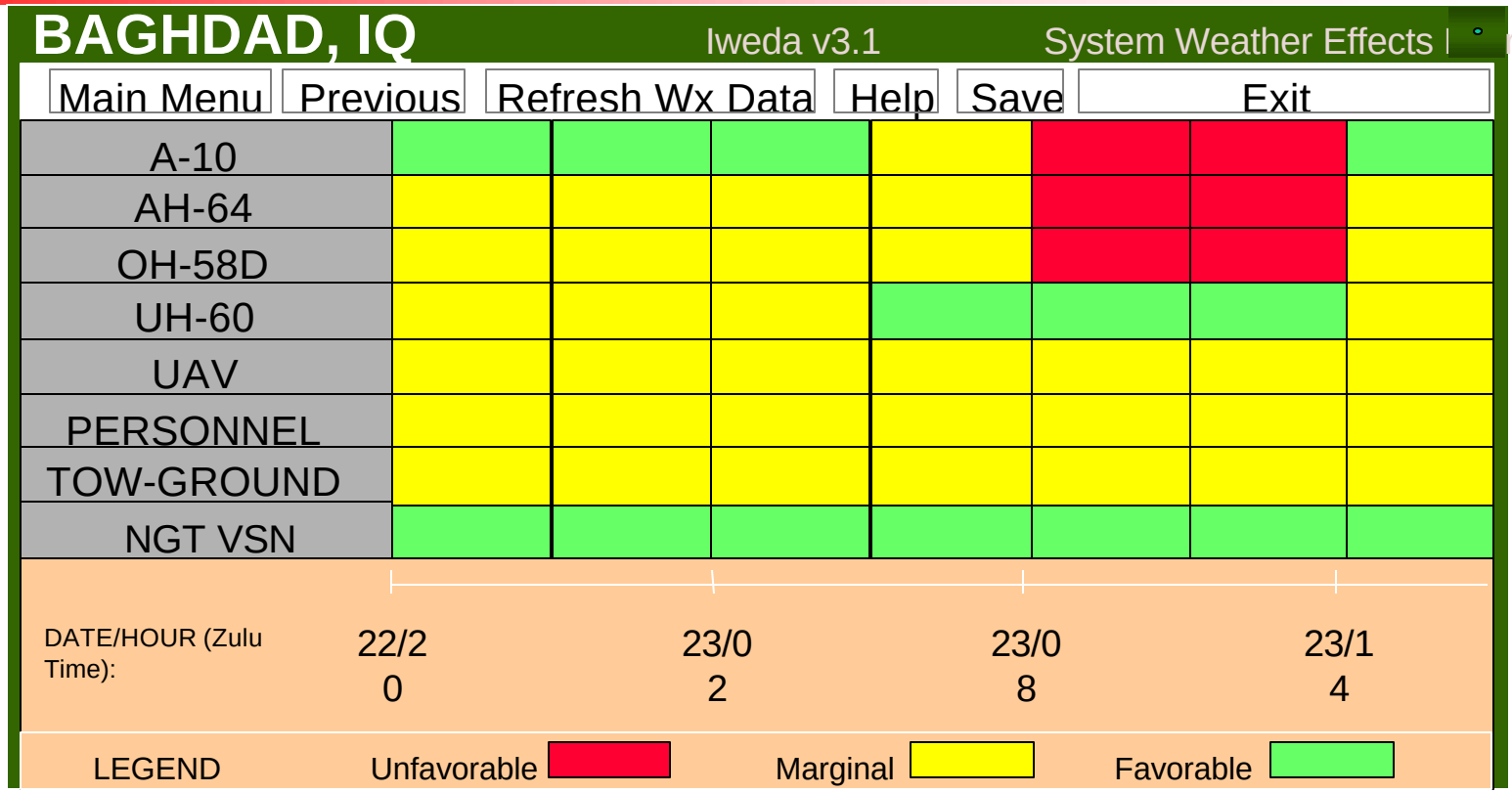
NCEP MRF Meteogram Near Seattle



MRF Upper Air Meteogram Near Seattle



TECHNOLOGIES:
Weather Effects Visualization
(Result of AF-Army Partnering)



IWEDA provides a stop-light representation of weather impacts on sensors, systems, platforms and operations at different times of the day based on critical value thresholds

WEATHER EFFECTS ON OPERATIONS

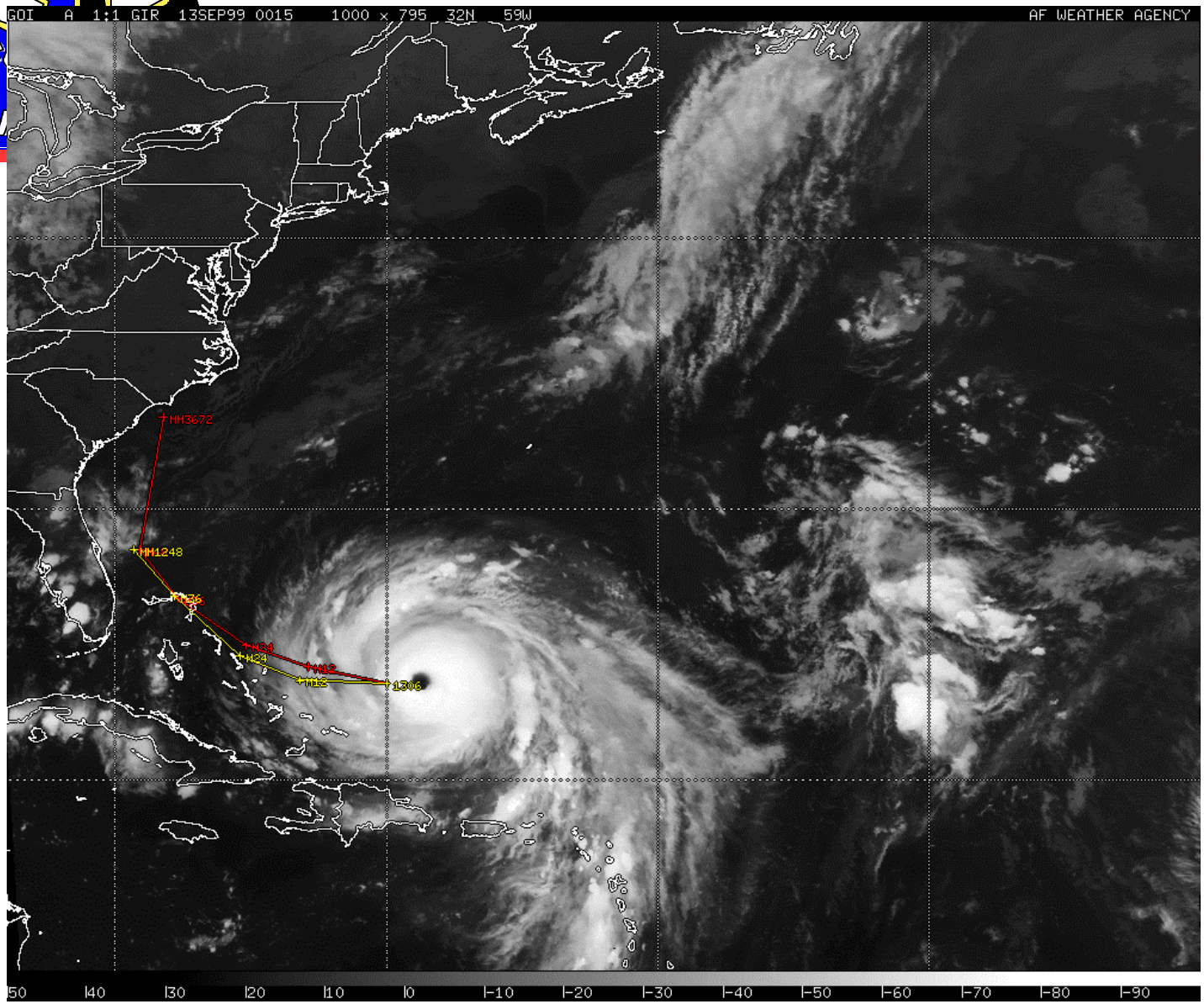
KOSOVO DAY 1

CREATED: 23 MAY 0200Z

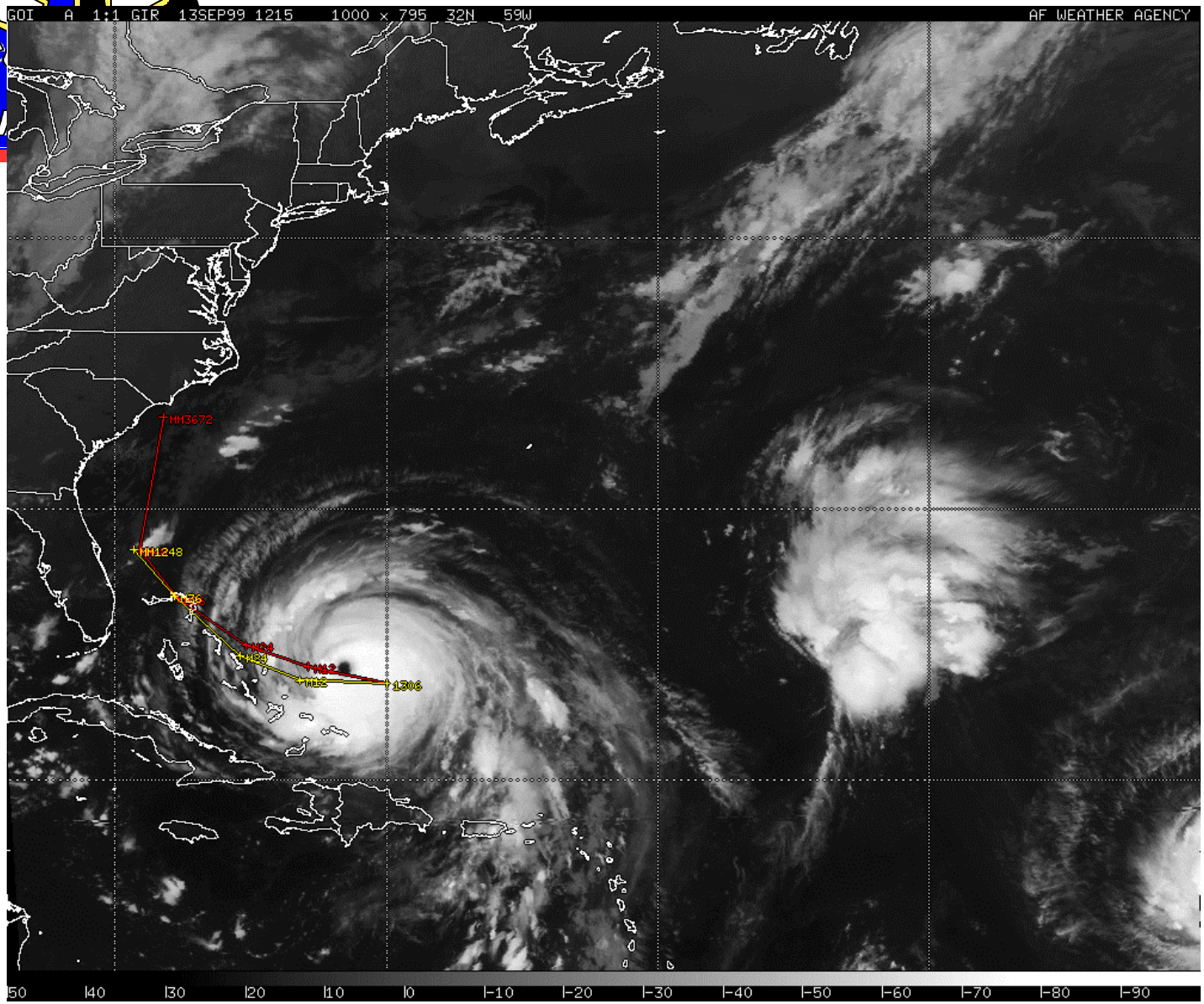
	23/02Z			08Z							14Z							20Z						24/02Z
STRATRECCE	F	F	F	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG
HI TACRECCE	F	F	F	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG
LO TACRECCE	M	M	M	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
	VIS	VIS	VIS	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG
CAS	F	F	F	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG
HELO OPS	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
TAC AIRLIFT	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
PERSONNEL	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
GROUND OPS	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	U	U	U	U	U	U
	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND
PGMs	F	F	F	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG

FAVORABLE MARGINAL UNFAVORABLE

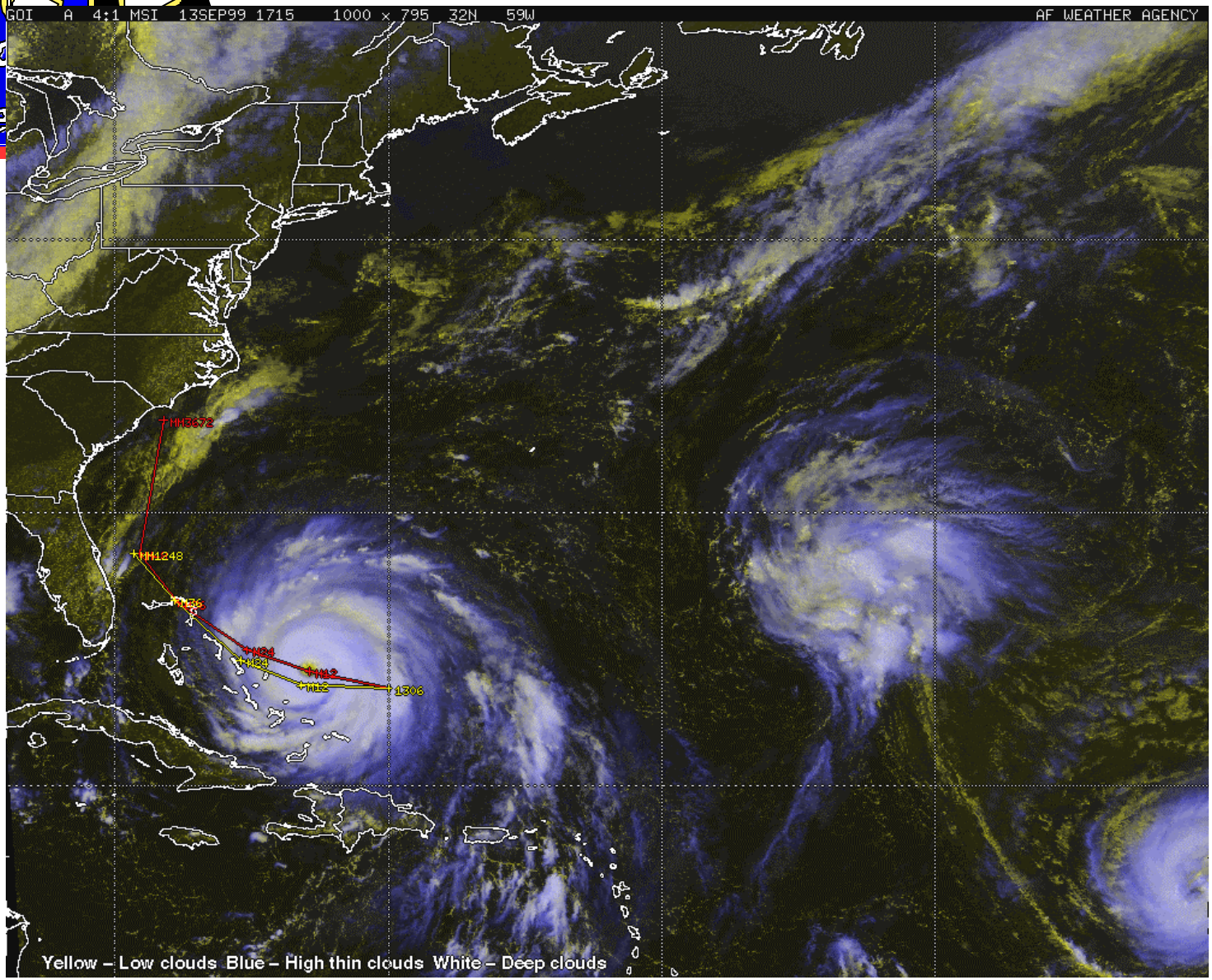
Hurricane Floyd - 13 September 1999, 0000Z



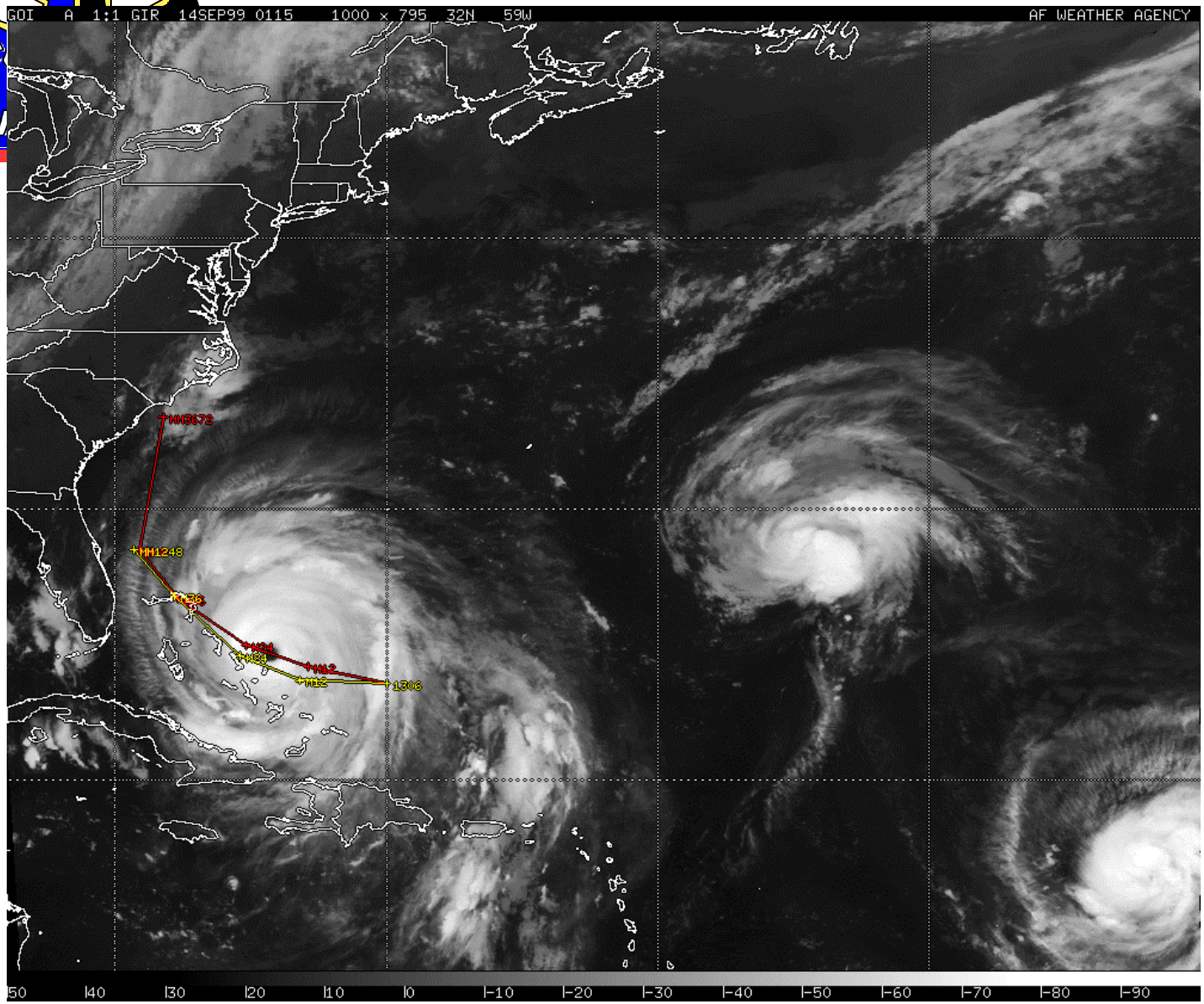
Hurricane Floyd - 13 September 1999, 1200Z



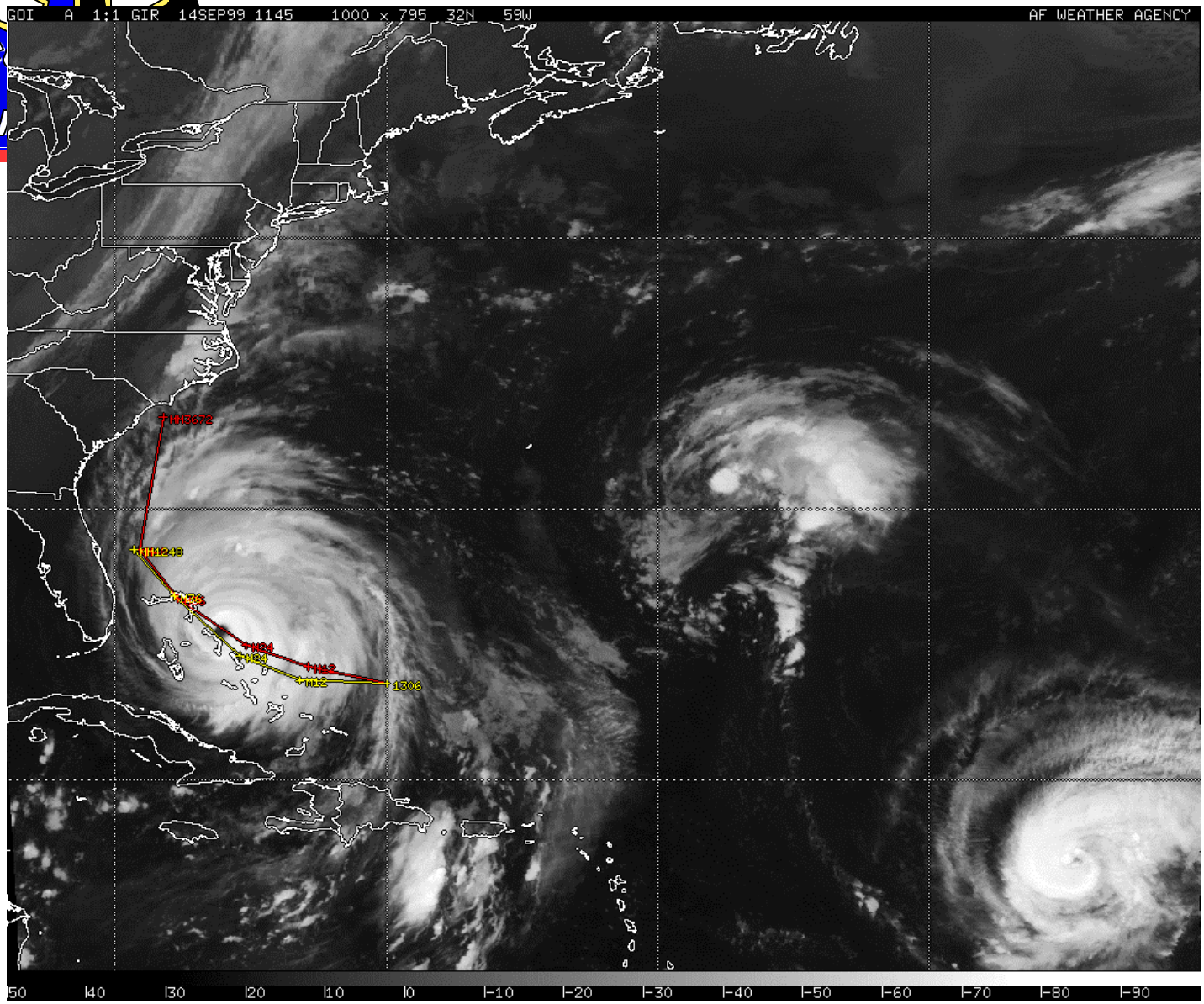
Hurricane Floyd - 13 September 1999, 1800Z



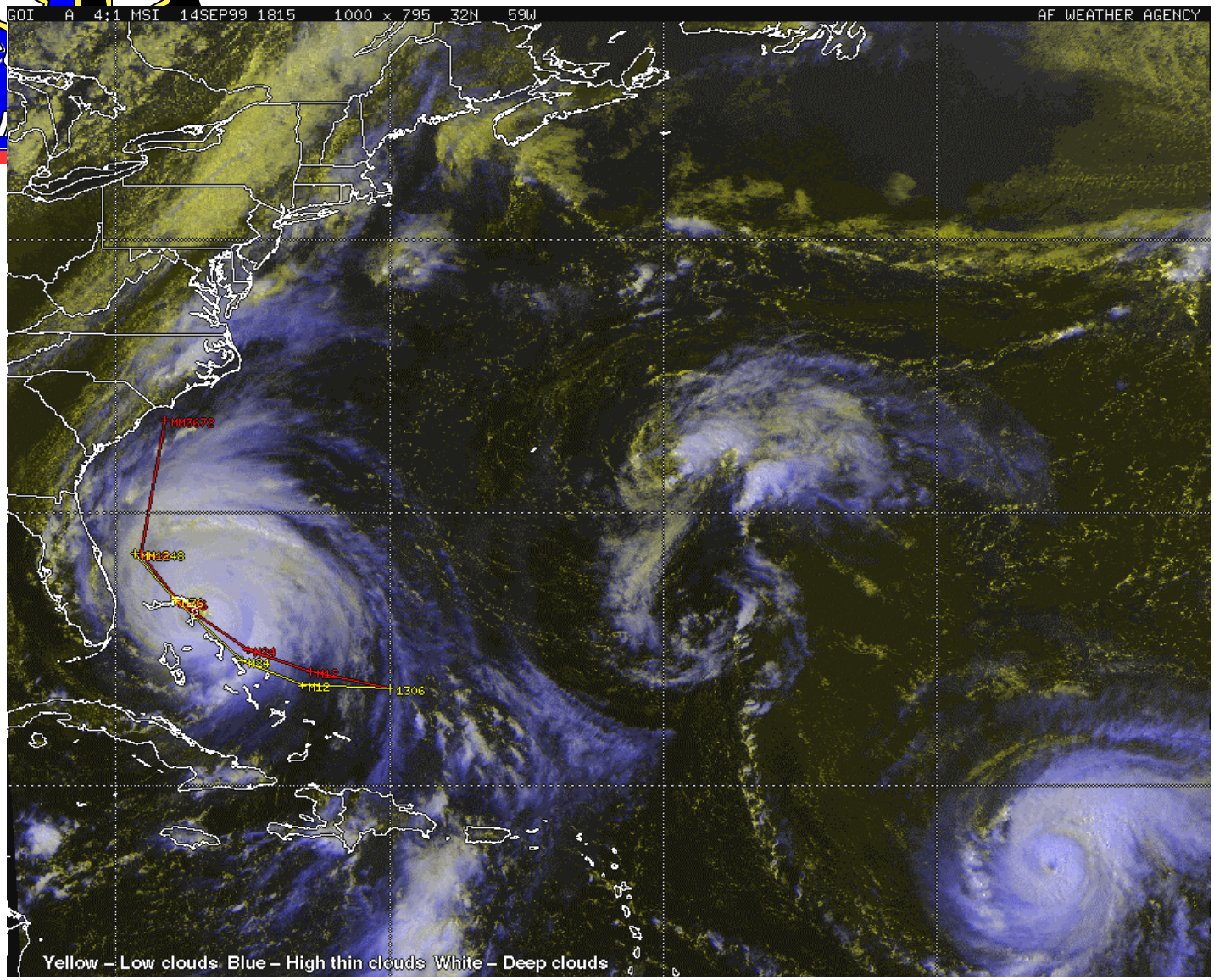
Hurricane Floyd - 14 September 1999, 0000Z



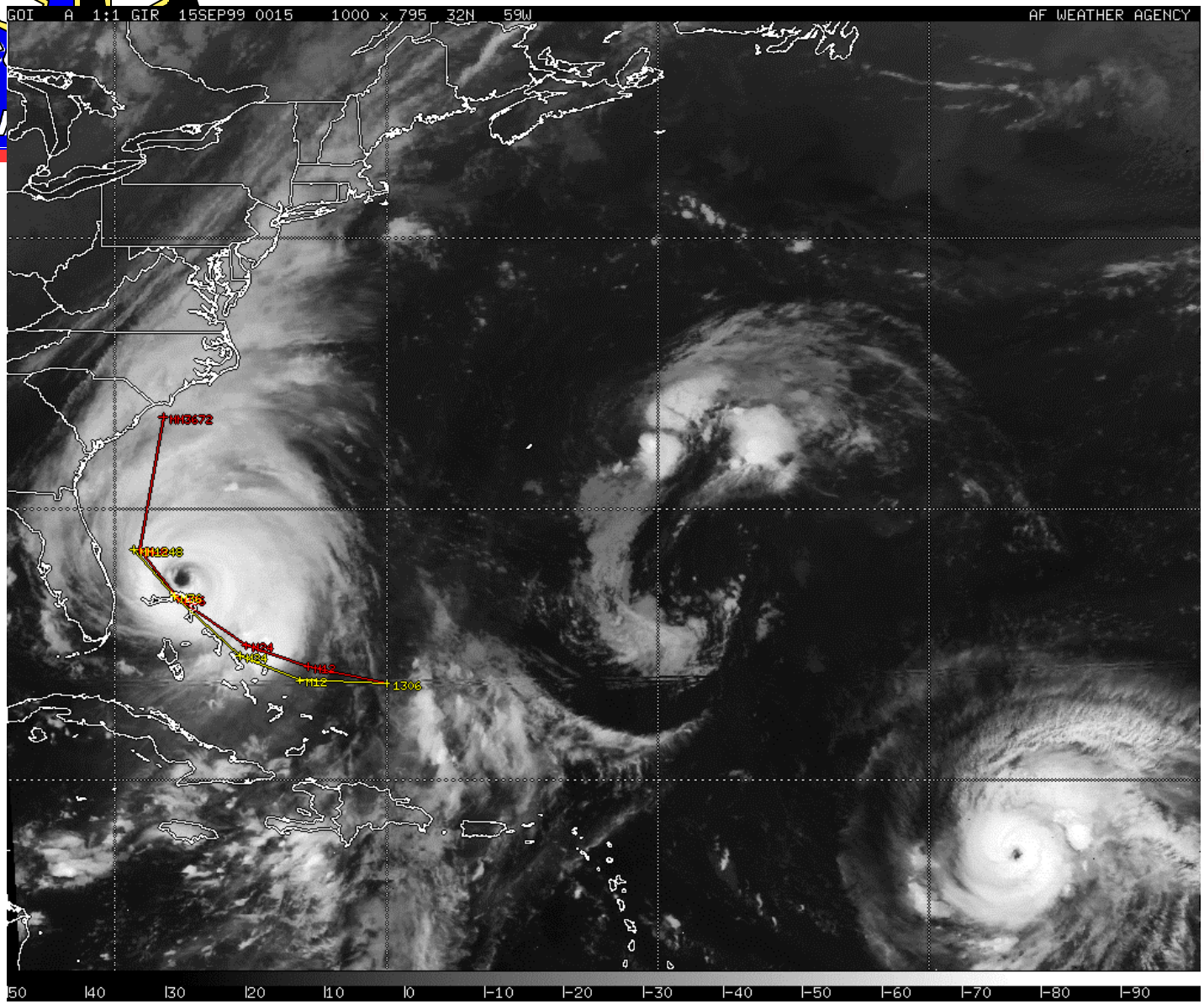
Hurricane Floyd - 14 September 1999, 1200Z



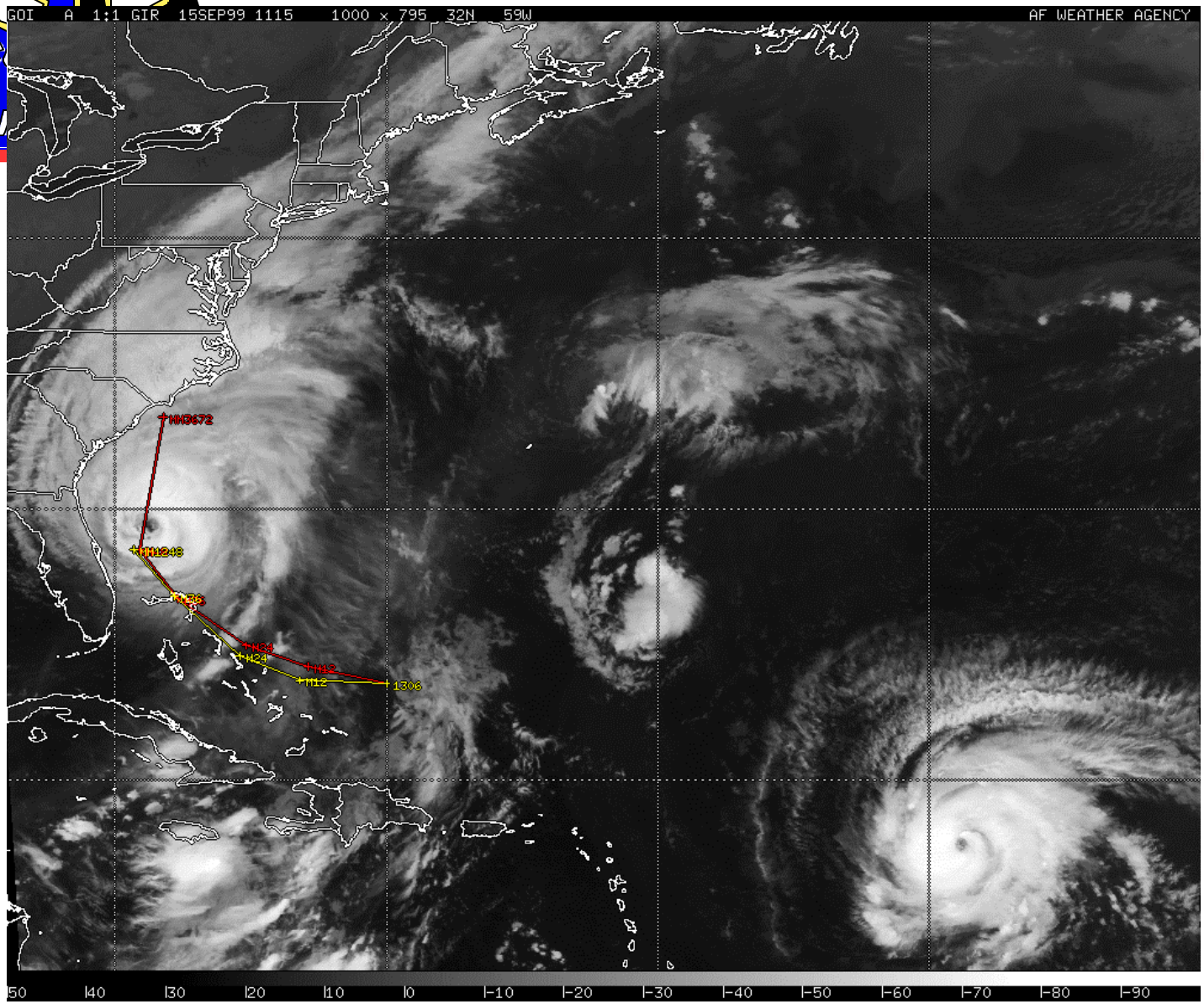
Hurricane Floyd - 14 September 1999, 1800Z



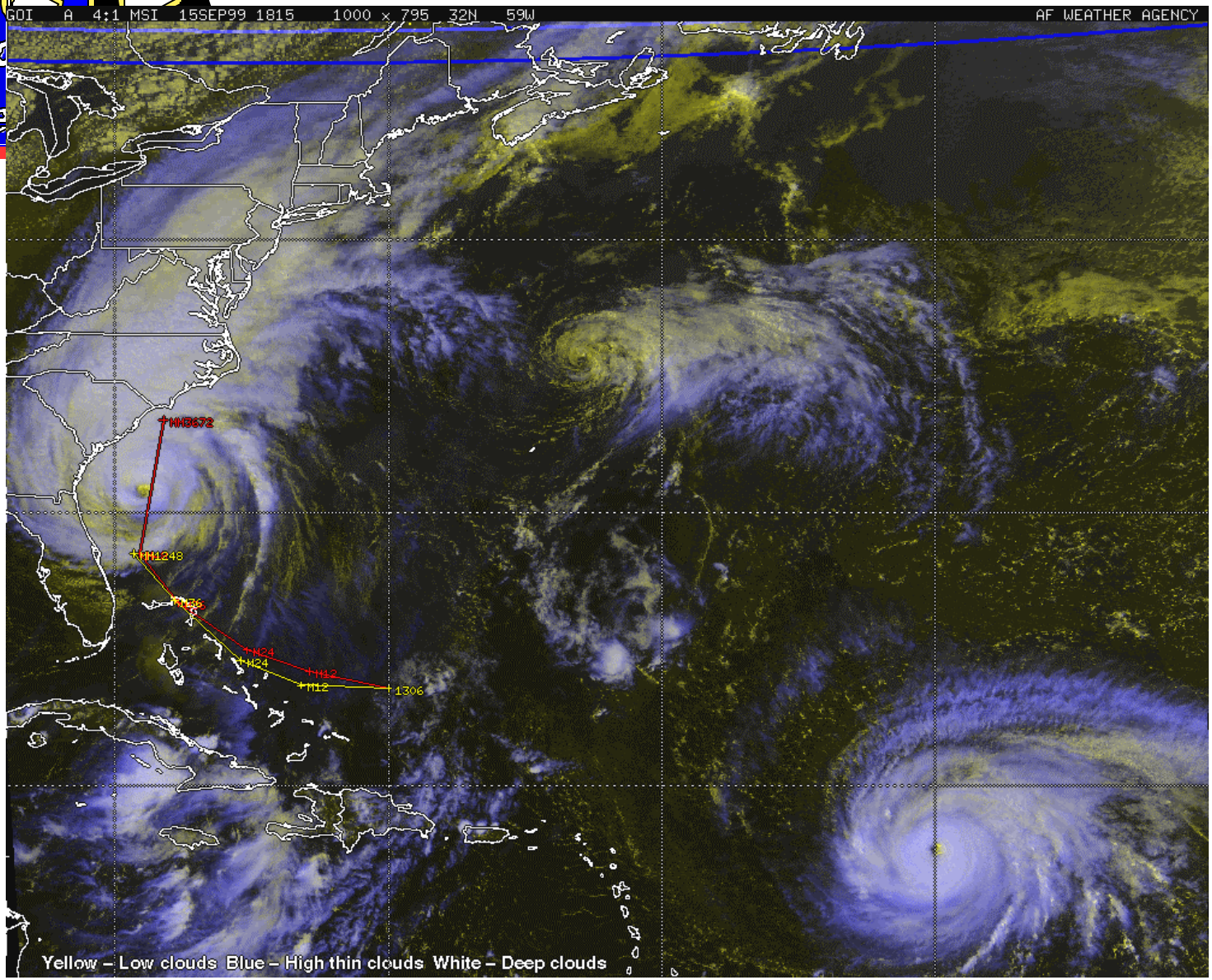
Hurricane Floyd - 15 September 1999, 0000Z



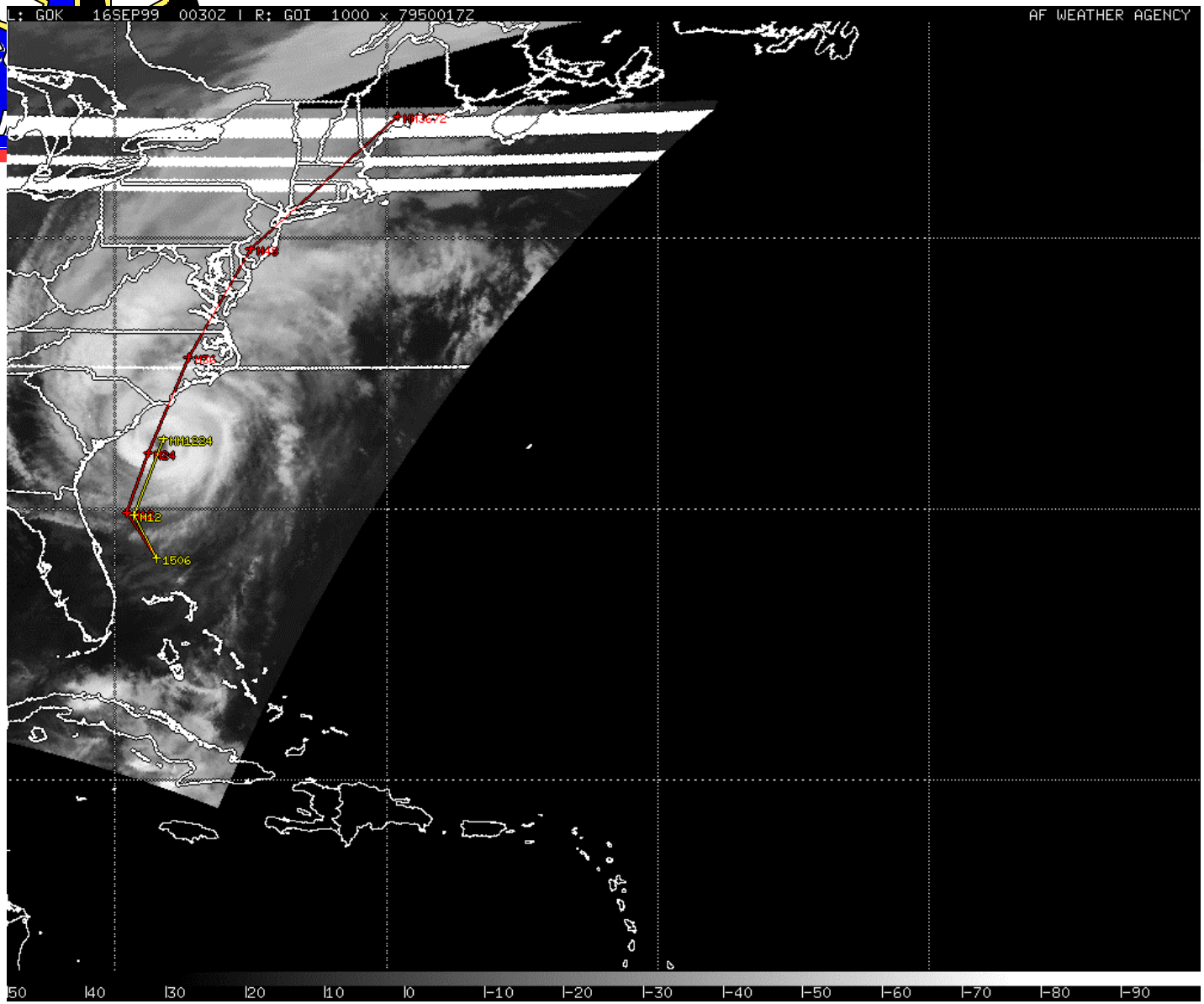
Hurricane Floyd - 15 September 1999, 1200Z



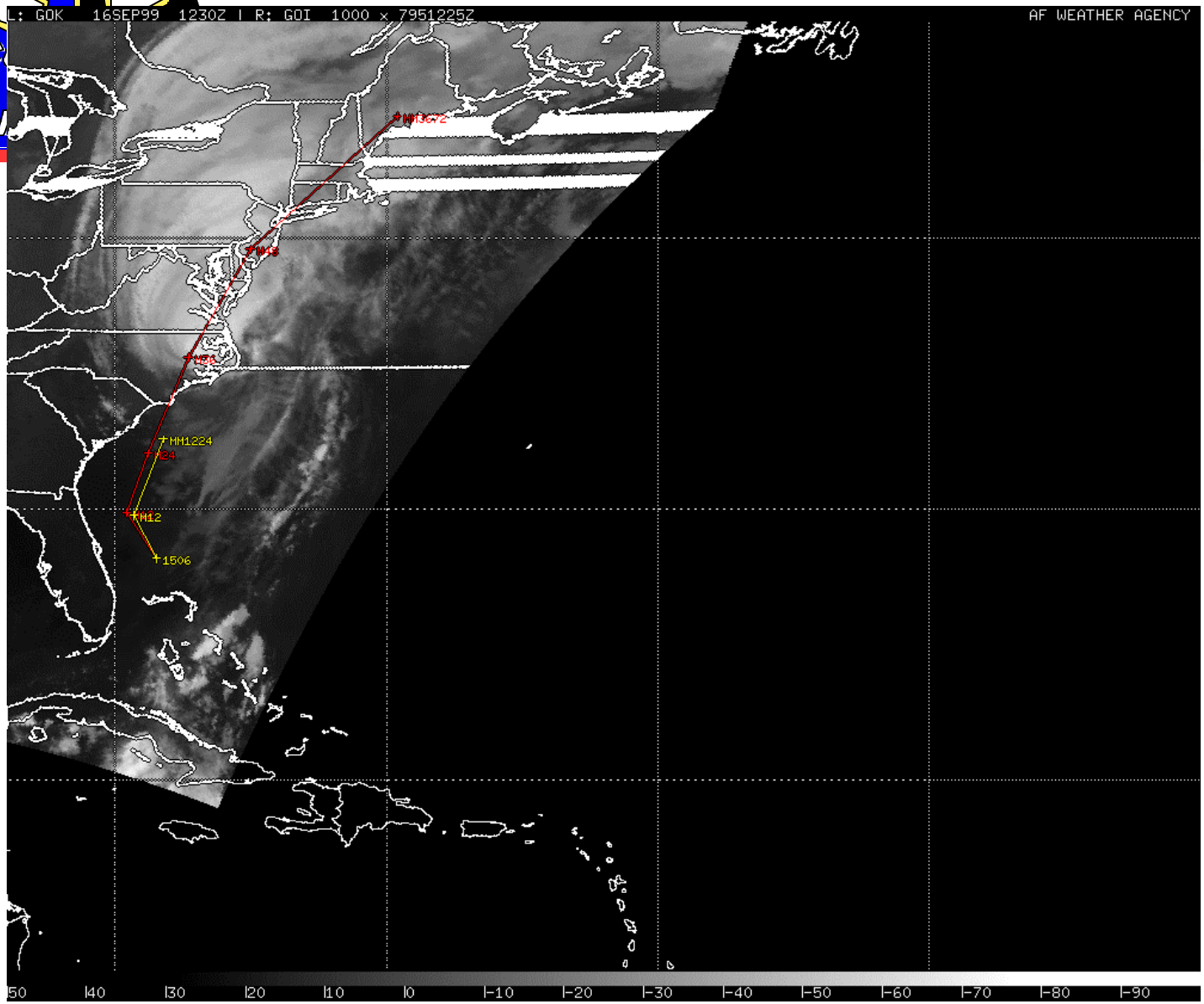
Hurricane Floyd - 15 September 1999, 1800Z



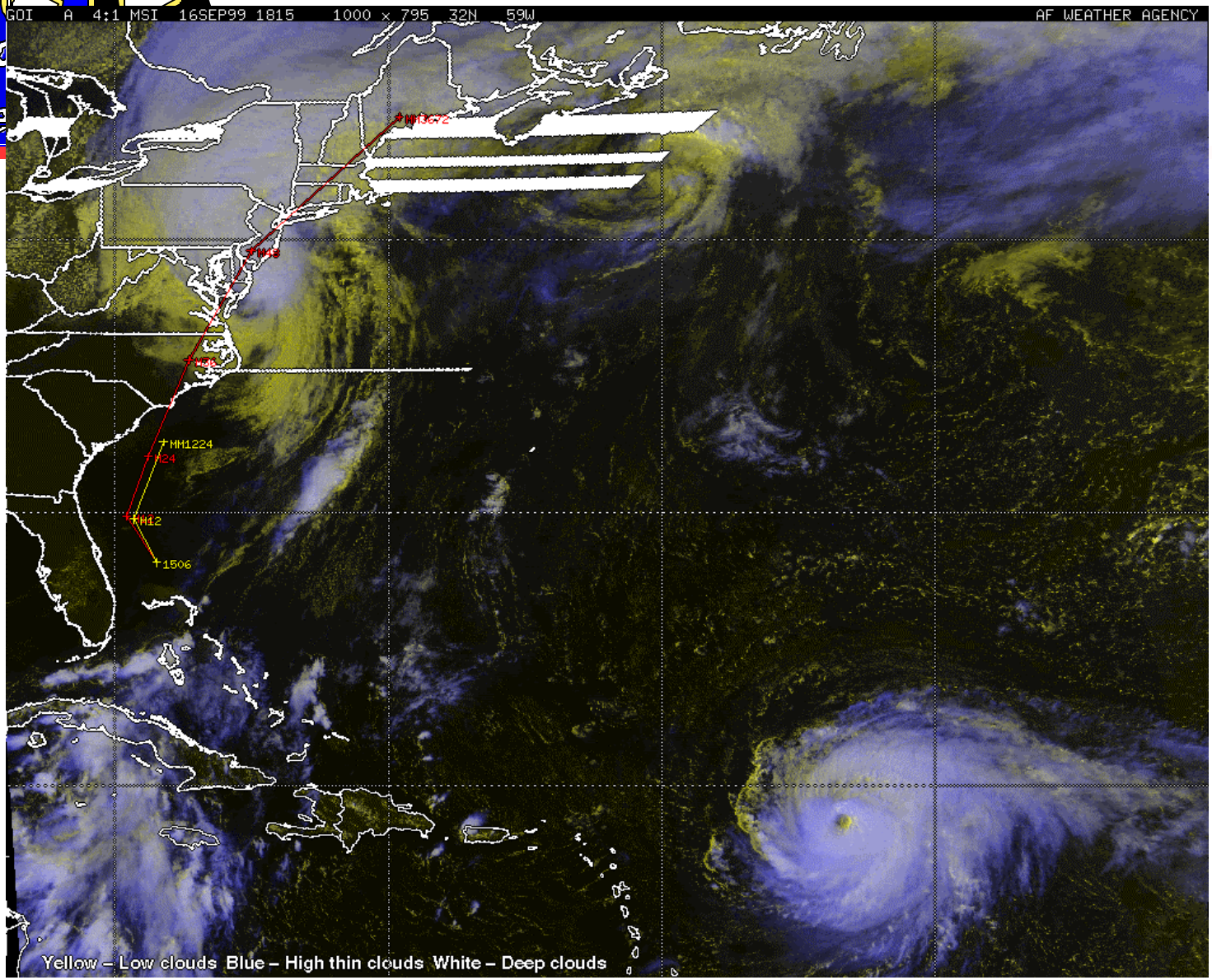
Hurricane Floyd - 16 September 1999, 0000Z



Hurricane Floyd - 16 September 1999, 1200Z

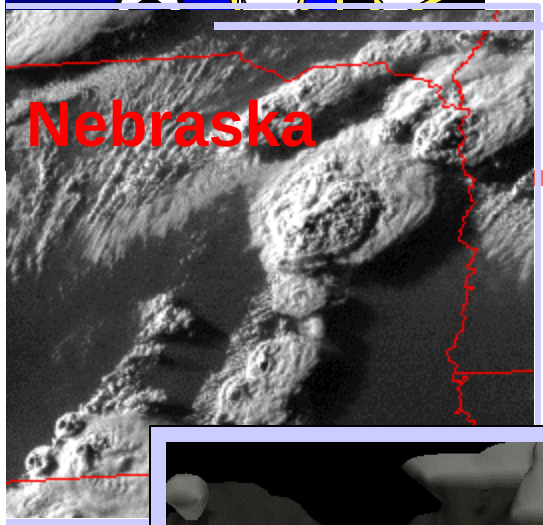


Hurricane Floyd - 16 September 1999, 1800Z

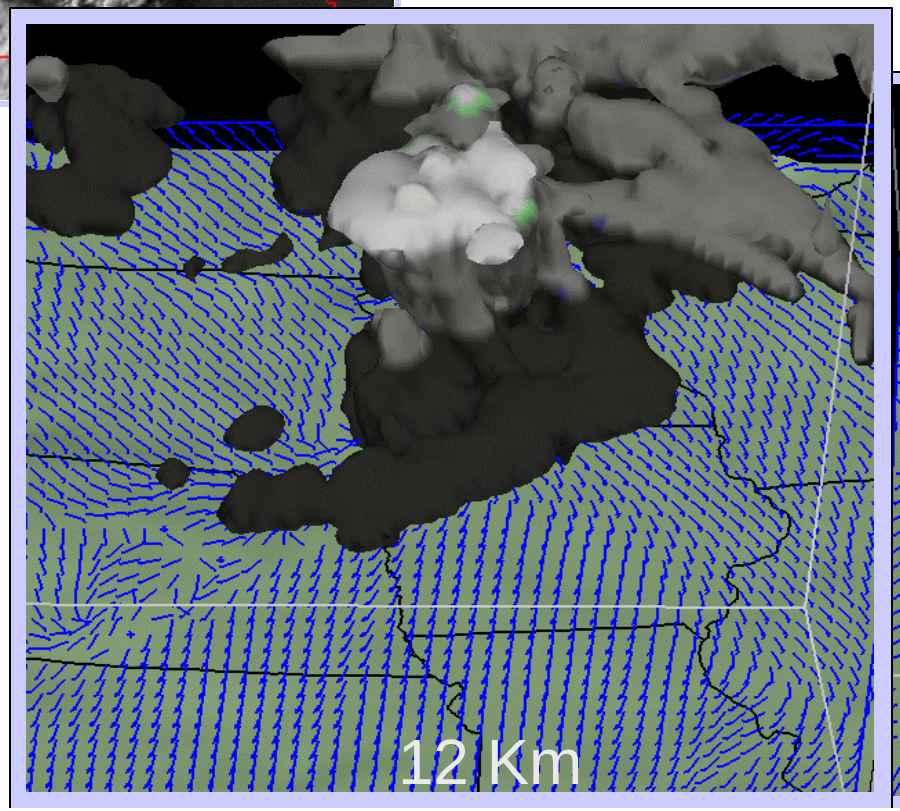


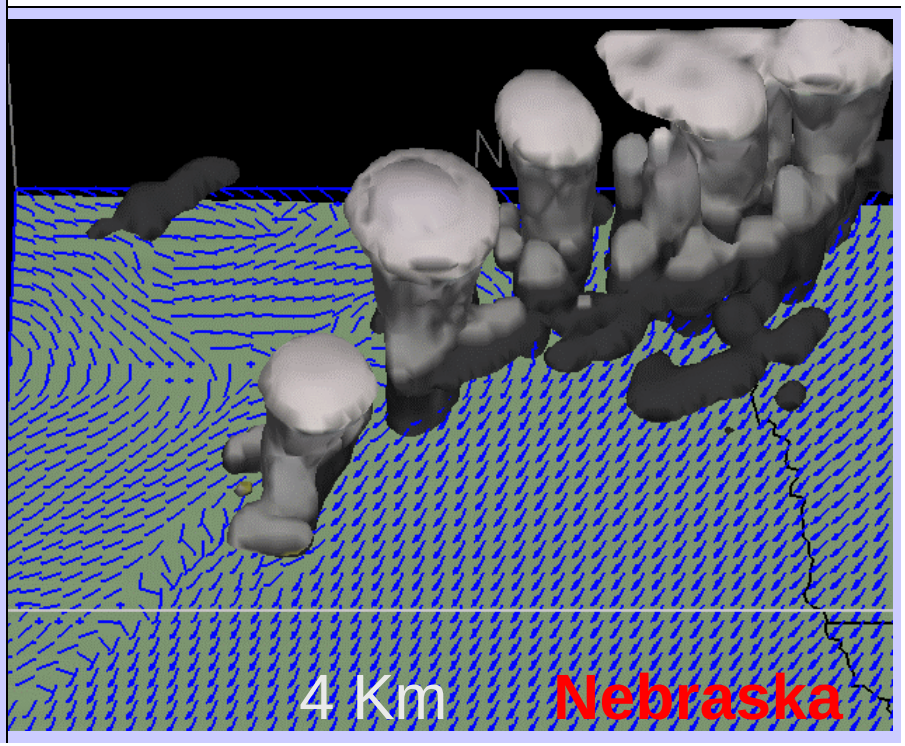
TECHNOLOGY

FINE-SCALE METSAT AND FORECASTING



Future of fine-scale weather forecasting is combining high-resolution satellite data with numerical weather prediction and producing visualizations with impact





SUMMARY

Weather and Surface Transportation

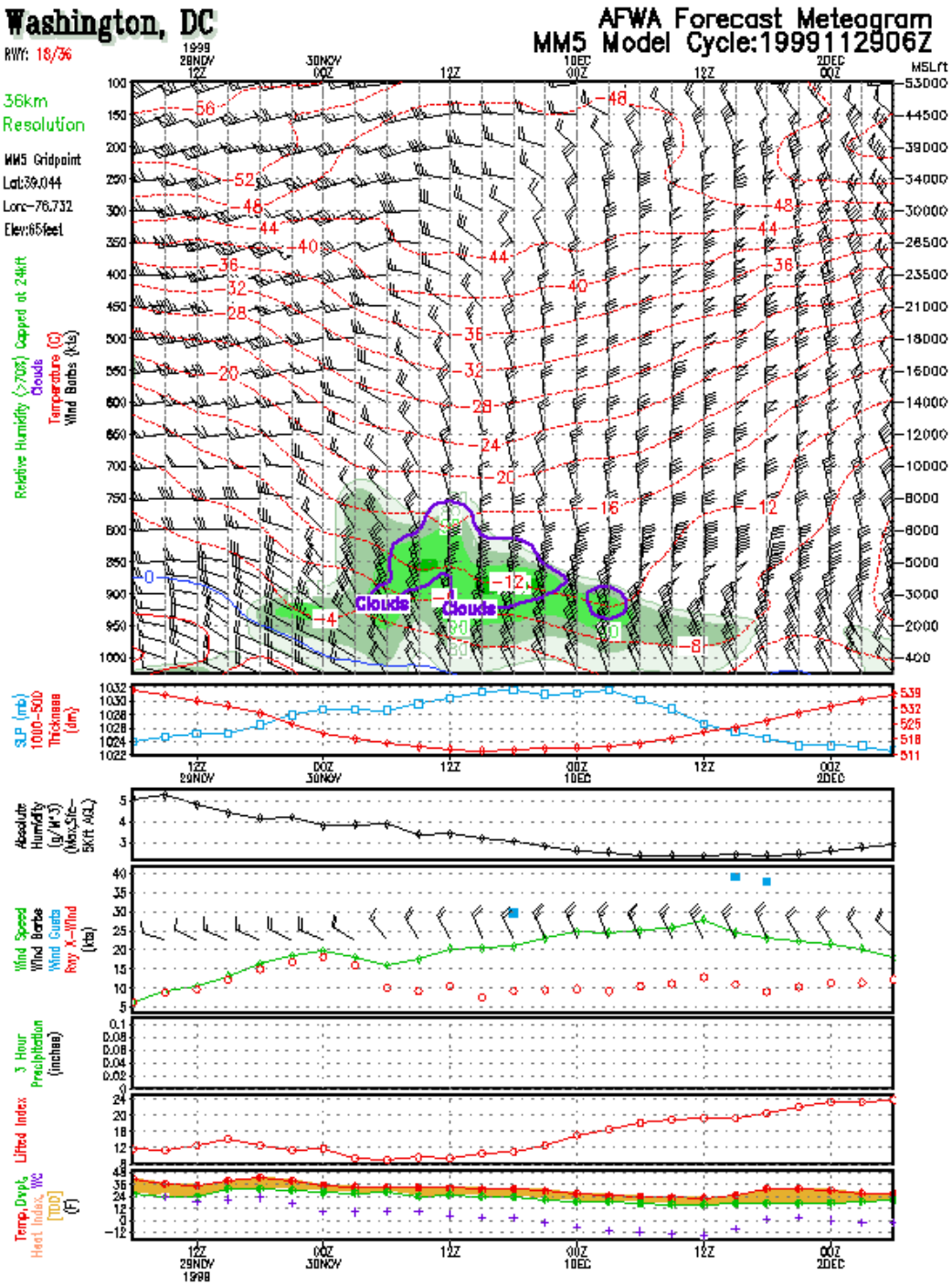
- Weather affects almost all human endeavor.
- What is important is not the weather itself, but the effect the weather has on the activity, operation or mission.
- Weather information that is timely, accurate and relevant to the activity can allow decision makers to anticipate and exploit opportunities for success and mitigate the impacts of mission-limiting weather.
- Very fine-scale, highly accurate forecast models, coupled with trained people, provide the keys to improved “mission effectiveness.”

BACK-UP SLIDES

Air Force Weather

MM5 Meteogram

Washington DC



It All Starts W
~3,600 PEOP

- Officer Meteorologists (20%)
- Enlisted Technicians (68%)
- Government Civilian Experts (7%)
- Contract Assistance (5%)
- 600 Guard + 100 Reservists

… and a mission to support Air Force, Army, and other designated DoD agencies land, air, sea, and space operations

AFWA Weather Models

- **Mesoscale Model 5 (MM5)** - theater weather model
  - Forecasts used to support Air Force and Army combat operations
- **Real-Time Nephanalysis (RTNEPH)** - cloud analysis
  - Analysis initializes cloud forecast models and used by Navy weather models
- **Surface Temperature (SFCTMP)** - temperature analysis and forecast
  - Input to RTNEPH cloud analysis (Air Force use)
- **Snow Depth Analysis (SNODEP)** - snow depth and age analysis
  - Input to RTNEPH cloud analysis, Navy, and National Weather Service models
- **Advect Cloud (ADVCLD)/High Resolution Cloud Prognosis (HRCP)-** cloud forecasts
  - Cloud amount forecasts used to support National Programs and combat operations
- **Atmospheric Slant Path Analysis Model (ASPAM)** - vertical profiles
  - Atmospheric profiles used to support National Programs and NBC dispersion
- **Agricultural Meteorology (AGRMET)** - analysis of surface parameters (soil moisture, etc.)
  - Surface parameters used to support National Programs and USDA

AFWA Weather Models

- **Mesoscale Model 5 (MM5)** - non-hydrostatic regional forecast model
  - 36/12/4 km horizontal resolution, 33 vertical levels
  - 36 km forecasts to 48 hours, inner nest forecasts to 24/12 hours
- **Real-Time Nephanalysis (RTNEPH)** - global analysis model
  - 25 nm horizontal resolution
  - Cloud amounts, bases and tops for 4 vertical layers, plus total cloud
- **Surface Temperature (SFCTMP)** - global analysis and forecast model
  - Analysis, 3-hour, and 4.5-hour forecast
  - 25 nm horizontal resolution
- **Snow Depth Analysis (SNODEP)** - global analysis model
  - 25 nm horizontal resolution
- **Advect Cloud (ADVCLD)** - global forecast model
  - Cloud amount at 5 levels plus total cloud
  - 25 nm horizontal resolution 0-12 hours, 50 nm horizontal resolution to 0-48 hours
- **Atmospheric Slant Path Analysis Model (ASPAM)** - point analysis model
  - Vertical profiles of temp, moisture, winds, aerosols, etc., available globally
- **Agricultural Meteorology (AGRMET)** - global analysis model
  - 25 nm horizontal resolution for 2 sub-surface layers (0-5 cm and 5-100 cm)

SPACE WEATHER

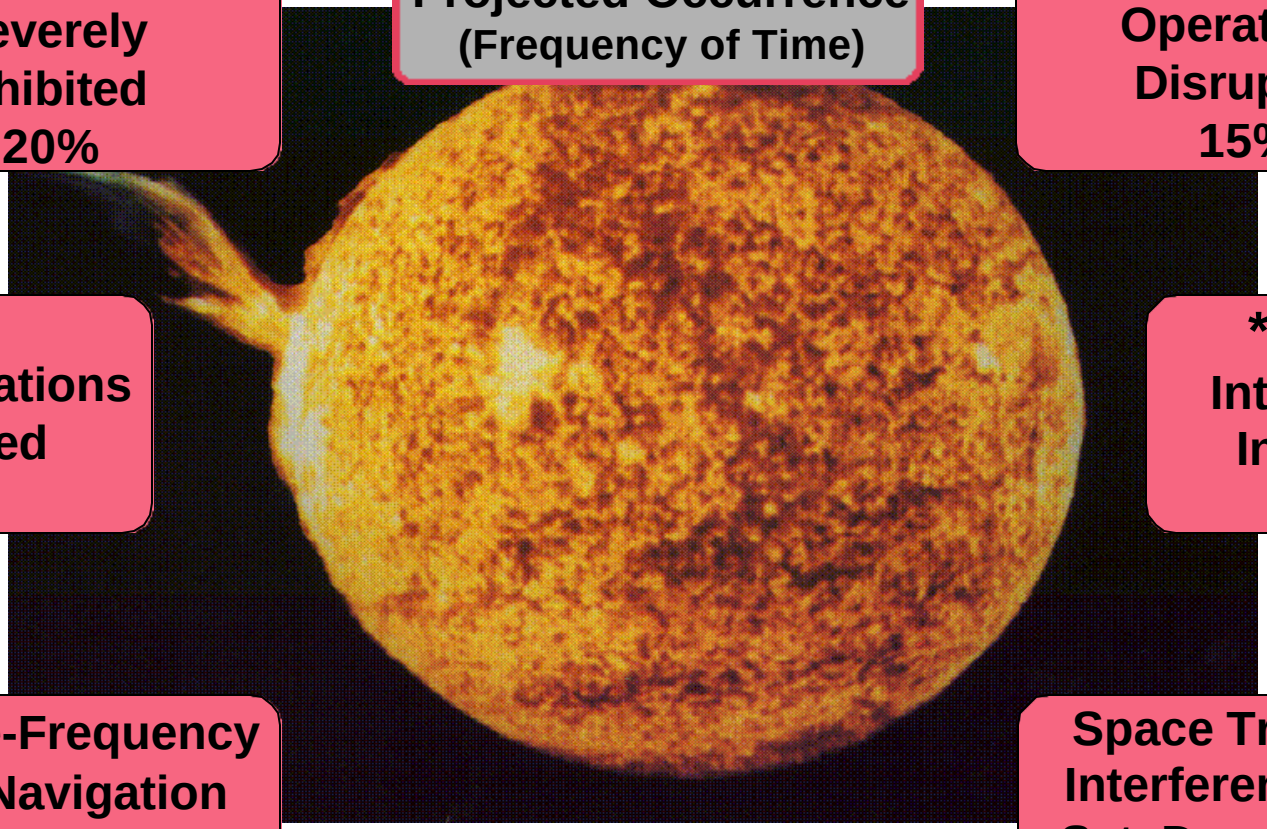
Key to 21st Century Warfare

RISK PROJECTION 2000

Projected Occurrence
(Frequency of Time)

***Geolocation Severely Inhibited 20%**

Satellite Operations Disrupted 15%



***HF Communications Disrupted 23%**

***SATCOM Intermittently Interrupted 13%**

***Single-Frequency GPS Navigation Significant Errors 20%**

Space Tracking Interference and Sat. Drag Events 11%

*** Projection is for SW Asia or Far East**

MILITARY METEOROLOGY

History: Origins

- Born in 1814 at the direction of the Army Surgeon General
  - Grown from physicians taking weather observations to the world's premiere military weather organization.
- Expanding telegraph networks and a growing military interest in meteorology brought weather services to the Army's Signal Service in 1870.
- The creation of the Signal Corps' Aeronautical Division in 1907 created new requirements for aviation support.
- With the dawning of World War I, the world quickly realized that weather impacts to modern warfare were significant, and that weather services were critical.

MILITARY METEOROLOGY

History: World War I

The rapid transmission by wireless of meteorological information is of the utmost importance…

General Erich F.W. Ludendorff

German General Staff, 1917

- British were intrigued at accuracy of German weather reports.
  - Germany's success was a direct result of weather observations being relayed by radio from submarines operating in the Atlantic Ocean.
- American military weather services were championed by Major General John J. Pershing and Brigadier General Billy Mitchell.
  - In 1917, Pershing requested meteorologists to support his American Expeditionary Forces in France.
  - Mitchell leveraged America's Signal Corps personnel and communications to produce accurate weather reports that became the basis of all orders for air operations.

MILITARY METEOROLOGY

History: World War II

Almighty and merciful Father…grant us fair weather for battle…
General George Patton, 1944

- General Arnold challenged the weather services for accurate and relevant long range forecasts to support global military operations.
- This set the stage for the most famous of all forecasts - in support of Operation Overlord -- the invasion of France in 1944.
  - General Eisenhower created a coalition weather team that had the greatest impact of any organization on the execution of the European invasion.
  - The team was keenly aware of the often contradictory joint mission conditions required.
  - The Allied weather team successfully predicted marginal conditions for the assault.
  - Achieved almost complete surprise because the Germans, denied weather information, expected the weather to delay any invasion.

MILITARY METEOROLOGY

History: Vietnam

This weather (satellite) picture is probably the greatest innovation of the war…

Lt General William Momyer, 1967

Never in the history of warfare have weather decisions played such an important role in operational planning as they have in Southeast Asia… **General Creighton Abrams, 1968**

- Unlike WW II, Weather organizations became physically and operationally separated from the operations centers
  - Target planning and integration slow and cumbersome
- New technologies presented greater environmental support challenges
- The Defense Meteorological Satellite Program (DMSP) developed to satisfy the need for higher resolution satellite data and imagery
  - Failure to integrate DMSP info into decision processes limited effectiveness
- When weather integrated into decision processes, results were positive
  - Integration in the rescue of US POWs at Son Tay resulted in moving the operation to the only usable day for over a month either side of the operation

MILITARY METEOROLOGY

History: Gulf War

- A critical lesson was learned during DESERT STORM: there are few benign environments in modern warfare.
- Even in a climatologically favorable environment, there are significant impacts.
  - Extremes in temperatures impacted sortie generation.
  - Clouds impacted tactical delivery techniques.
  - Abnormal precipitation impacted ground operations.
- DESERT STORM called the first “space war” because of the expanded use of weather, navigation, early warning, and surveillance satellites.
- DESERT STORM occurred during the third largest solar maximum on record.
  - First “space war” was conducted in a significantly hostile natural environment.
- During the 41 day war, 81 major solar flares occurred.
  - Flares degraded performance of communication systems for minutes to hours.
  - In addition solar flares and other space environment phenomena affected SATCOM and UHF communication during the evening hours.

MILITARY METEOROLOGY

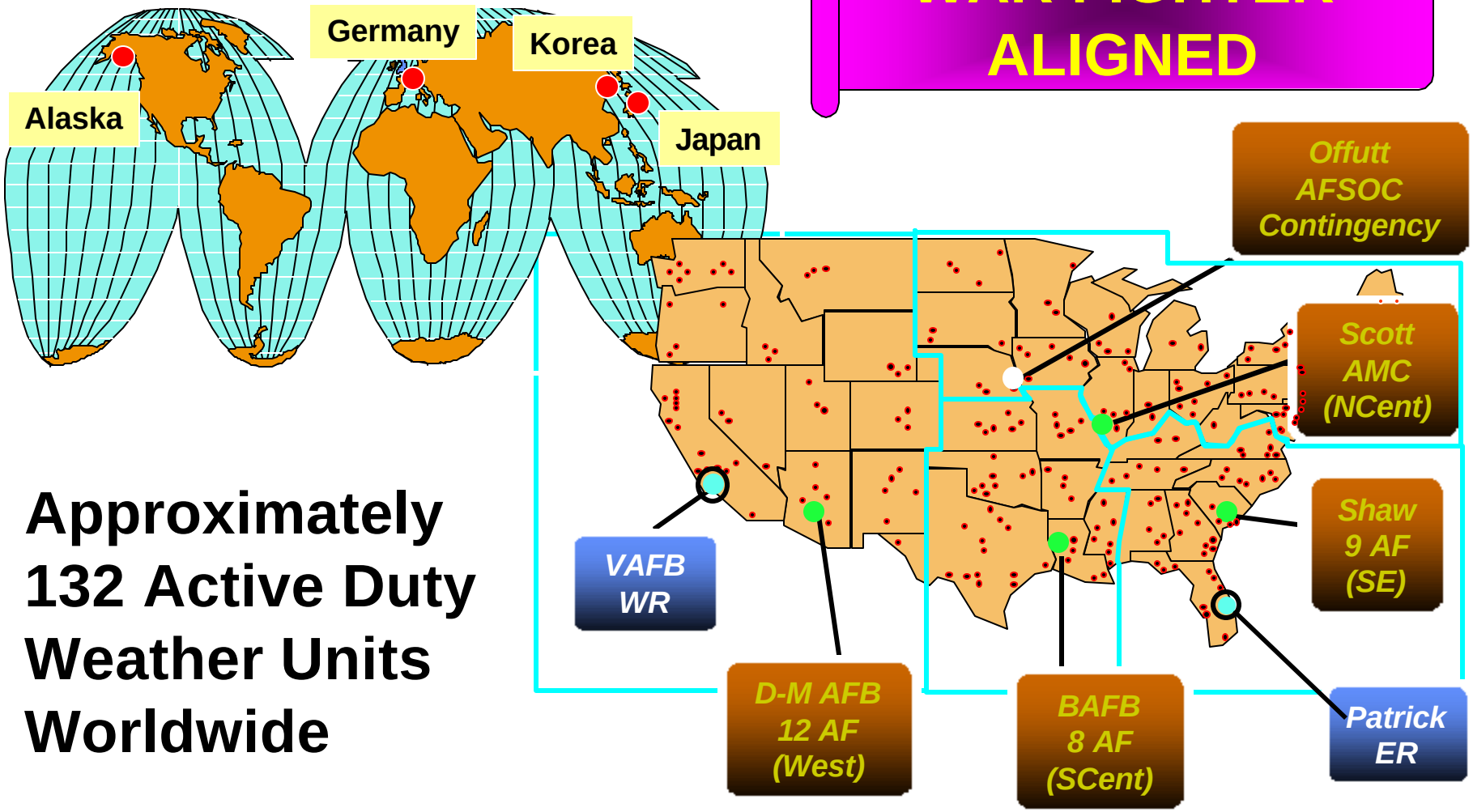
Military Operations Other than War

Air & space weather support is vital across the spectrum of warfighting. Contrast our Son Tay example with the failures at Desert One, the failed Iranian hostage rescue, where Air Force Weather personnel were not allowed to brief the crews local climatology or the execution weather. In Desert One, the opportunity for weather personnel and aircrews to determine mission thresholds and tailor the forecast to mission needs was lost. More challenging conditions, like those encountered in Bosnia, will affect deployment and employment operations. Effective planning will prepare alternative courses of action for the operations commander.

AFW ARCHITECTURE

Operational Weather Squadrons

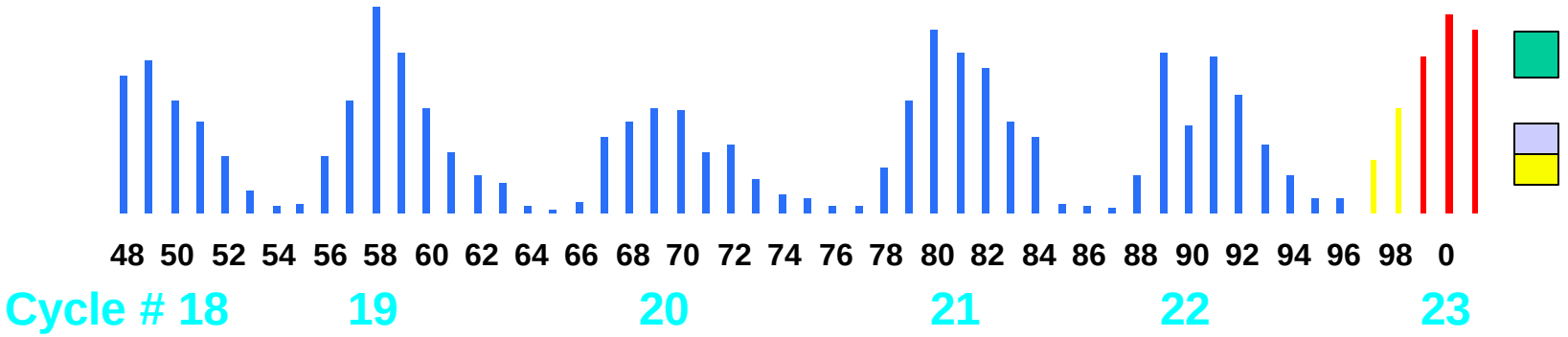
WAR FIGHTER ALIGNED



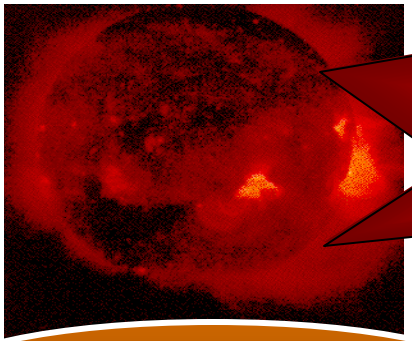
Approximately 132 Active Duty Weather Units Worldwide

TECHNOLOGIES:
SPACE WEATHER

Solar Cycle



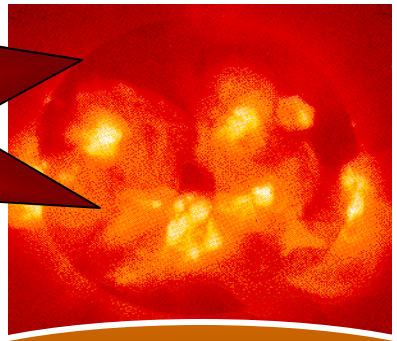
Solar Minimum (1996)



"Quiet" Sun

Expect Cycle 23 to be the Most Disruptive in 40 years

Solar Maximum (1999-2002)



"Disruptive" Sun

MM5 12km Cloud Tops/Surface Winds

24 Hr Forecast Valid 30 Nov 06Z